# JPL 1990-3: A 5-nrad Extragalactic Source Catalog Based on Combined Radio Interferometric Observations

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A combined analysis merges 17,000 DSN Very Long Baseline Interferometric (VLBI) observations with 303,000 observations from the Crustal Dynamics Project (CDP) and the International Radio Interferometric Surveying (IRIS) project. Observations from the Radio Reference Frame Development (RRFD) and Time and Earth Motion Precision Observations (TEMPO) programs through late 1990 form the DSN VLBI data set. The combined analysis yields angular coordinates of extragalactic radio sources with a precision of a few nanoradians, as compared with 5- to 10-nrad precision for coordinates derived in the past solely from DSN data. The improvement in the combined analysis is due to the new Mark III DSN data, as well as to increased statistical strength from the large volume of observations from non-DSN experiments. Such a unified analysis is made possible by recent improvements in parameter estimation software efficiency. The terrestrial reference frame is based on joint VLBI experiments employing both DSN and CDP antennas, and on specifying the coordinates of VLBI antennas in a proper geocentric coordinate system by means of Global Positioning System (GPS) collocation of VLBI, LLR, and SLR (Lunar and Satellite Laser Ranging) sites. Approximately 200 sources, fairly uniformly distributed over the sky at declinations ranging from -45 to +90 deg, form the 1990-3 catalog, and show formal uncertainties smaller than 5 nrad. At this level of precision, it is critical to estimate corrections to the International Astronomical Union (IAU) models of precession and nutation, and the 1990-3 source positions should only be used in conjunction with these corrections. Furthermore, at this level, a number of ignored effects, such as tropospheric turbulence and source structure, may cause errors equal to or greater than the formal uncertainties. Attempts to assess the influence of unmodeled systematic errors by comparing source positions with catalogs derived from independent analyses of partially independent data place a lower limit of 2 to 3 nrad on currently achievable accuracies. This leads to a realistic estimate of the true level of accuracy of approximately 5 nrad for this combined radio source catalog.

#### I. Introduction

This work emerged from a comparison of the models and analysis techniques employed by Goddard Space Flight Center (GSFC) and JPL groups [1]. Subsequently, it became of interest to determine whether adding non-DSN data to the analyses for radio-reference frame development could compensate for the reduced availability of the DSN antennas for Very Long Baseline Interferometry (VLBI) in the late 1980s. A further goal was to determine how much is to be gained by adding non-DSN data to the databases determining previously published JPL source coordinates [2,3], as well as to the more recent DSN-only data including several thousand Mark III observations [4]. By mid-1990 the total number of VLBI observations available for processing at JPL had exceeded 300,000. Recent improvements in JPL analysis software have made it possible to perform least-squares estimation involving hundreds of thousands of observations and tens of thousands of parameters within a few days of CPU time on VAX-780-class computers. It was therefore decided to generate a radio source catalog from all the VLBI data available in order to assess its suitability for meeting navigation requirements.

Three current projects demand celestial or terrestrial reference frames at or exceeding the accuracy levels of current frames. Proposed Galileo tracking requirements specify a radio reference frame stable to 5 nrad, while preliminary specifications for Ka-band tracking of Cassini tighten this requirement to 3 nrad. The TOPEX-POSEIDON project requires 3-cm three-dimensional baseline accuracy, with 5-cm alignment with the geocenter. This translates to 3 nrad on the California-Australia baseline. Thus, navigation requirements in the near future are more stringent than the accuracy level of 10 nrad for the DSN reference frame published in 1988 [2], and also go beyond the more recent DSN source catalogs [3,4].

The Crustal Dynamics Project (CDP) and International Radio Interferometric Surveying (IRIS) programs always perform multiple baseline experiments, with much more frequent observing sessions than those of the DSN. Consequently, the number of CDP+IRIS observations is more than an order of magnitude larger than the number of DSN observations generated by the Radio Reference Frame Development (RRFD) and Time and Earth Motion Precision Observations (TEMPO) projects at JPL. The CDP and IRIS networks also provide a considerably different geometrical coverage of the Earth than the three DSN complexes, and may thus serve to expose any systematic effects which depend on network geometry.

The combined VLBI database consists of 319,734 observations. In addition to being one of the largest data sets used for estimation of astrometric and geodetic parameters, it also provides a diverse set of baseline lengths and orientations. A long-standing weakness of all current VLBI data is the paucity of observations by stations in the southern hemisphere. This is especially true of the CDP and IRIS measurements throughout the 1980s; the DSN has benefitted from the Tidbinbilla station, which permits sky coverage down to -45-deg declination. On the other hand, all the non-DSN data have been acquired with Mark III recording systems, which have only recently (1988) been introduced into the DSN. The larger DSN antenna diameters and lower system temperatures, however, produce markedly reduced system noise and observable errors in current DSN Mark III data relative to CDP and IRIS data.

Aside from possible systematic errors, the radio source positions reported here form one of the best-determined extragalactic source catalogs presently available, which is a candidate for a fundamental reference frame. Discussions are under way in various International Astronomical Union (IAU) working groups, which are expected to adopt (in 1994) a radio reference frame to replace the present optical-based frame as the fundamental reference frame for astrometry. Such considerations are driven by the realization that uncertainties of the best optical measurements presently exceed the best radio interferometric uncertainties by at least an order of magnitude: <5 nrad (radio) versus ≈100 nrad (optical) [5]. When the next generation of optical astrometric measurements of galactic sources becomes available from the Hipparcos project [6], optical uncertainties are expected to be reduced to 10 nrad. Unlike the extragalactic radio sources, however, most galactic optical objects show considerable proper motion. As a result, the source positions reported here form a more stable reference frame than Hipparcos. During the next few years, additional experiments by the astrometry groups at the Naval Research Laboratory (NRL) and the U.S. Naval Observatory (USNO), as well as other current projects, are expected to improve precision further and to provide more nearly uniform sky coverage by including southern hemisphere observations.

This article presents a description of the analysis of combined VLBI observations. Section II summarizes the interferometric data from the four projects that are employed to generate the combined source catalog. Details such as distribution of observing sites, noise characteristics, and elevation angles serve to characterize the observations. VLBI modeling, analysis, and parametrization are discussed in Section III, while Section IV gives a sum-

mary of the results most pertinent to specification of radio source coordinates for spacecraft navigation. Section V attempts an assessment of the influence of unmodeled systematic errors in order to arrive at realistic estimates of the true level of accuracy of the combined radio source catalog.

#### II. VLBI Data

Only data from experiments employing hydrogen maser frequency standards and dual-frequency (S- and X-band, 2.3 and 8.4 GHz) ionosphere calibration are considered here. This means that no data prior to 1978 are included. Mark III VLBI systems [7] were used in acquiring all the CDP and IRIS data, and Block I systems [8] were used in TEMPO, while Mark II systems<sup>1,2</sup> were employed in RRFD experiments until late 1988 to early 1989, with Mark III used thereafter.

A short summary of the four observing programs that are considered in this article is presented in Table 1. Further details concerning data acquisition, reduction, and analysis are given in [9] for the GSFC CDP data, and in any current IRIS monthly bulletin [10] for the National Geodetic Survey IRIS data. Here, N<sub>stn</sub> is the number of unique stations, and  $N_{bsl}$  is the number of unique baselines. Note that no distinction is made among various antennas at the three DSN complexes (marked with asterisks). The number of observing sessions is  $N_{ses}$ ; these are normally of 24-hr duration (except for the post-1987 RRFD and the 3-hr TEMPO sessions), and may involve as many as seven stations. The number of unique sources observed in each program is  $N_{src}$ . The major thrust of the first three observing programs of Table 1 is geodetic, while the RRFD program is predominantly astrometric, as can be seen from the  $N_{bsl}$  and  $N_{src}$  columns. An order of magnitude more observations of relatively few sources by CDP, and especially IRIS, may contribute more to determination of short-period nutation amplitudes than to improving the accuracy of source positions. Finally,  $N_{obs}$ is the number of pairs of delay (D) and delay-rate (DR) measurements that are included in the analysis. The analysis described here used data available in the fall of 1990; by early spring of 1991, the number of RRFD MkIII observations had tripled, and they are being incorporated into the database for a future source catalog. A total of 230 extragalactic radio sources contributed observations. The number of observations per source ranges from a maximum of 23,656 (for 4C 39.25) to 1 (for five sources for which RRFD observations had only recently begun).

Two broad characterizations of the data involve datanoise and elevation-angle distributions. Table 2 shows the root-mean-square delay data noise (formal uncertainty from correlation processing) for each observing program, as well as the additional noise (constant for each baseline in a given observing session) that was root-sum-squared with the observable noise in order to approximate chisquare per degree of freedom = 1 in the least-squares fit (see Section III). Note that for TEMPO data, additional noise is introduced as an RSSed fraction of the total tropospheric delay contribution for each observation [4], rather than as an RSSed constant for each observing session. The RRFD data are subdivided into Mark II and Mark III categories because there is a large difference in their data quality. While the data quality also generally improves with time from the late 1970s to 1990 for all observing programs, there is no such clear demarcation for CDP, IRIS, or TEMPO.

It can be seen that both the data noise and additive noise are considerably lower for CDP and IRIS data than for RRFD MkII and TEMPO data. The RRFD MkIII data, on the other hand, exhibit the lowest value in both categories. Comparison of data noise and additive noise is not straightforward because of variations in scan lengths and fractions of low-elevation observations among the observing programs. Variation of the additive noise may indicate problems either with the receiving or recording systems, correlation processing, data editing, or the postcorrelation software that generates the observables. Noise added to account solely for unmodeled physical effects is not expected to vary with the type of data if similar observing schedules are used. The strength of the DSN data as a whole lies in the larger antennas and variety of sources observed, as well as the generally longer baselines and more complete declination coverage. The DSN observations also benefit from quieter receiving electronics, given equivalent recording systems. These characteristics permit the 17,000 DSN observations to make a nearly equivalent contribution, on the whole, to that of the 300,000 CDP+IRIS observations in the combined fit.

Low-elevation-angle observations were avoided in early non-DSN VLBI experiments because of problems in modeling the large tropospheric delays at low elevations. As a result, there is a scarcity of data at elevation angles below 15–20 deg in the early CDP and IRIS data. The DSN experiments, partly because they were performed over longer baselines, routinely involved observations down to the an-

<sup>&</sup>lt;sup>1</sup> E. J. Cohen, "VLBI Bandwidth Synthesis Manual," JPL Tracking Systems and Applications Section report (internal document), June 1979.

<sup>&</sup>lt;sup>2</sup> E. J. Cohen, "VLBI Rack Manual," JPL Tracking Systems and Applications Section report (internal document), May 1980.

tenna limits of 6-deg elevation throughout their entire history. Now that improved troposphere models are available [11,12], and it is commonly accepted that mismodeling of the time-varying tropospheric delay is a limiting error source in interpretation of VLBI results [13], and that low-elevation observations help to model and reduce the static part of this error, CDP and IRIS experiments also routinely acquire substantial numbers of low-elevation observations. Table 3 shows an overall summary of the four observing programs in terms of the fractions of observations involving elevation angles smaller than 10, 20, and 30 deg  $(f_{10}, f_{20}, \text{ and } f_{30}, \text{ respectively})$  at any participating station. It may be seen that both  $f_{10}$  and  $f_{20}$  are larger by approximately a factor of 3 for RRFD and TEMPO than for CDP and IRIS observations. Well over half of the DSN observations are made at elevations below 30 deg.

Two analyses of comparably large VLBI data sets have been recently carried out by Ma and co-workers [14,15]. These two catalogs are based respectively on 237,000 and 461,000 observations, with the second including NAVNET (the geodetic VLBI program of the USNO) and southern hemisphere astrometric data in addition to CDP and IRIS experiments. There is necessarily considerable overlap between those two databases and the one used in the work described here. Comparison of estimated source positions indicates the magnitude of discrepancies due to differences in observables, modeling software, and analysis techniques.

#### III. Modeling and Data Analysis

With some exceptions, theoretical modeling of the observed delays and rates conforms to the specifications contained in the International Earth Rotation Service (IERS) standards [16]. The data quality demands a model for the Earth's precession and nutation that goes beyond the current IERS and IAU standards [17]. Details are given below, and a more complete description of modeling is given in the document concerning the JPL VLBI software "MODEST" [18]. Briefly, the calculations are performed in solar system barycentric coordinates defined in terms of the mean equator of J2000.0.

The clock and troposphere modeling options were the same as those used in the 1988 source catalog paper [2]. The clock model was piecewise linear, with breaks introduced only in places where they appeared essential from inspection of the post-fit residual patterns. At most stations, this averaged to 5 or 6 clock sections per 24 hr. Improved instrumental stability reduces this by at least a factor of 2 for RRFD Mark III data. Troposphere modeling was piecewise constant, with a new value of the zenith

delay estimated at each station for every 3 hr of observations. It remains to be determined how much error in source coordinates is introduced by such parametrization.

UT1 and polar motion (UTPM) values were fixed at those given by the uniformly smoothed time series of Gross and Steppe [19], which is consistent with the 1989 IERS UTPM reference frame [20]. These Earth-rotation parameters are accurate to 1 to 2 nrad during the latter part of the time span covered by the VLBI data. The coordinates of the reference station (Gilmore Creek, Alaska) were taken from the CDP Annual Report for 1989 [9] at the epoch 1988.0. These coordinates are specified in terms of a current best-estimate geocentric system, established in recent years by means of comparison of VLBI, SLR, LLR, and GPS measurements [21]. Positions at epoch 1988.0 are estimated for 30 stations (all but the reference station). Except for Gilmore Creek, time rates of change are also estimated for the coordinates of all stations for which the data cover a sufficient time span (19 stations in all).

Note that the adoption of a terrestrial reference frame poses a consistency problem in analysis of large data sets. Considerable portions of the data used here have also gone into the results of all the references cited in the previous paragraph. Achieving truly independent fixes of the terrestrial coordinate system and the UTPM series would necessitate the adoption of results of techniques totally independent of VLBI. Satellite and lunar ranging techniques, however, are presently not capable of providing all the required parameters at an acceptable accuracy level.

Similar considerations apply, to a somewhat lesser degree, to the method used to circumvent the right ascension reference problem for VLBI data. The origin of celestial coordinates was fixed by tightly constraining the right ascension and declination of OJ 287 and declination of CTD 20 to their values in the IERS 90C01 celestial reference frame [20]. Instead of the usual single right ascension constraint, three coordinates are constrained in order to allow for improved nutation and precession models, and to make the overall orientation of the estimated coordinate system be close to IERS 90C01. It was noted from previous experience that alternative choices of terrestrial and celestial origins have little effect on the relative source coordinates. Nutation modeling is a known weak point of the present IERS standards, which use the 1980 IAU nutation series [17]. The position of the celestial pole is known to depart from the 1980 IAU value by as much as 25 nrad [4,22,23]. The quality of present VLBI data demands that this inadequacy be compensated by some means. Consequently, it was decided to estimate values of the precession constant and selected nutation amplitudes.

Ecliptic longitude  $(\psi)$  and obliquity  $(\varepsilon)$  define the position of the celestial ephemeris pole (CEP) at a given epoch. The estimated components of the nutation model were the amplitudes of the nutations with selected periods in both longitude and obliquity. There is evidence [24] that effects of ocean tides and friction at the core-mantle boundary cause small contributions to nutation that are out of phase with those of the current IAU model, which was derived for an oceanless Earth. Consequently both in-phase and out-of-phase components were considered. Amplitude corrections  $\Delta A_{th}$  and  $\Delta A_{\epsilon}$  of a total of nine nutation periods were estimated: 18.6 yr, 9.3 yr, 365.3 d, 182.6 d, 121.7 d, 27.6 d, 13.7 d, 13.6 d (respectively, terms 1, 2, 10, 9, 11, 32, 31, and 33 of the total of 106 in the 1980 IAU series), and the free core nutation with a period of 433.2 d. These particular frequencies include at least all the terms which have been found to require amplitude corrections in previous work [22,23]. Exploratory fits on various subsets of the present database have shown that the 18-yr, annual, and semiannual terms give a good representation of the daily corrections to the CEP position ( $\Delta \psi$  and  $\Delta \varepsilon$ ) determined from the data. The remaining terms are included here in order to uncover other, possibly significant corrections. With 4 components per period, the total number of estimated nutation amplitudes was 36. In order to constrain the celestial ephemeris pole at epoch J2000 to its nominal position, two angular offsets (rotations about the x and y axes) were also estimated. These represent, respectively, displacements of the CEP toward 18- and 0-hr right ascension. The method used here for defining the celestial reference frame and for estimating precession and nutation follows [4].

A linear least-squares algorithm is used to obtain optimal estimates of the model parameters from data. The least-squares estimation is achieved with the square-root information filter (SRIF) algorithms of Bierman [25]. The software is presently implemented on VAX computers and workstations, which were used in the fit described in this article. Several days to a week of CPU time is required to complete the analysis. Disk storage requirements are also quite sizable (≈0.5 Gbytes), mostly due to the large number of source coordinates that enter each fit as global parameters. To minimize CPU and storage requirements, the analysis was done in six sections: two CDP, three IRIS, and one RRFD/TEMPO, with no section containing more than 70,000 observations. The basic fit estimates 57,795 parameters from the 319,734 pairs of delay and delay-rate observables. Of these, only the 460 source coordinates, 39 nutation/precession quantities, and 294 station positions and rates were global parameters. The final combined results are identical to what would be obtained by performing the fit in a single step [25].

The least-squares parameter estimation is weighted by a covariance matrix of the observables that is diagonal. The diagonal elements are inversely proportional to the square of the observable error. Such effects as uncalibrated instrumental errors, troposphere fluctuations [13], and source structure [26-28] introduce additional unmodeled noise. In order to partially account for these inadequacies, sessionspecific adjustable errors are introduced. As mentioned in Section II, these are root-sum-squared with the observable errors, and adjusted in order to make the normalized chi-square for each session close to 1.0. For delays, this additive noise ranges from a few to tens of picoseconds for Mark III observations, to several hundred picoseconds for some of the early Mark II and Block I sessions. As mentioned before, the variation of additive noise may indicate possible problems in instrumentation, correlation, or postcorrelation processing that need to be investigated further.

#### IV. Results

The overall goodness of fit is indicated by rootmean-square (RMS) residuals of 123 psec for delays, and 100 fsec/sec for delay rates. These are distributed among the component data sets, as shown in Table 4. Generally, the residuals fall into two classes: Mark II (TEMPO and RRFD) and Mark III (CDP, IRIS, and RRFD). The noticeably better IRIS DR residuals may originate in the smaller proportion of IRIS low-elevation observations. Since this article focuses on the celestial reference frame, three categories of estimated parameters (clock, troposphere, and station location) will not be considered in detail here. The first two categories (clocks and tropospheres) will be subject to future scrutiny in order to better characterize their stochastic behavior. Station coordinates at epoch 1988.0 are generally determined with formal uncertainties of ≈2 to 20 mm, and their linear time rates of change with uncertainties of  $\approx 1$  to 5 mm/yr. The rates agree with the Minster-Jordan AM0-2 [29] and NU-VEL [30] models of tectonic motion at the level of a few mm/yr. Naturally there is an intimate relationship between the models of UTPM and tectonic motion, which needs to be explored more critically in future work.

Not counting the two reference sources (OJ 287 and CTD 20), coordinate estimates are made for a total of 230 sources. Positions of 216 of these sources are listed in Table 5, including the number of observations, average observing epoch, and correlation coefficient between right ascension and declination. Note that the source coordinates are given in the traditional units of hours, minutes, and seconds for RA, and degrees, minutes, and seconds for dec-

lination ( $\delta$ ). Approximate conversion factors to nanoradians are  $72\cos(\delta)$  nrad/msec for RA and 4.8 nrad/mas for  $\delta$ . Fourteen sources with  $1\sigma$  declination uncertainties that exceed ≈20 nrad are not included in Table 5. On the other hand, the Table includes 23 sources with fewer than 10 observations, whose coordinates should be considered preliminary. Most of these are sources for which DSN observations have been initiated only recently. Nevertheless, approximately half of these sources have  $\sigma$ 's smaller than 5 nrad. To give the reader some idea of the quality of this catalog, it contains 40 sources that were observed more than 1000 times, 54 sources with formal declination uncertainties  $(\sigma_{\delta})$  smaller than 1 nrad, and a majority (178) of the sources have  $\sigma_{\delta} < 5$  nrad. The catalog is named JPL 1990-3, in conformance with the local naming convention which categorizes catalogs by date of analysis.

Figures 1(a) and (b) show histograms of the formal uncertainties of JPL 1990-3 divided into 0.25-nrad bins. For comparison, similar histograms are shown in Figs. 2(a) and (b) for the current TEMPO catalog, JPL 1991-1 [4], which is based on DSN data through early 1991. It is seen that the errors of 1991-1 bear some resemblance to single-peaked distributions, while the heterogeneous nature of the observations entering 1990-3 spreads out the error distributions considerably and introduces multiple peaks.

Table 6 shows the precession and nutation parameters (in units of nanoradians) derived from the fit which yield JPL 1990-3. Note the highly significant precession correction. The x and y celestial ephemeris pole offsets are listed in the  $\Delta A_{\psi}$  and  $\Delta A_{\varepsilon}$  columns, and show that the CEP at J2000 is significantly shifted, approximately toward 5.5 hours RA. There are sizable significant corrections to the 1980 IAU nutation amplitudes at 18-yr, 9-yr, annual, and semiannual periods, including a number of out-of-phase components. A number of the shorterperiod nutation amplitudes are not significant, judging by the given formal uncertainties, but are included for completeness. A long-standing problem in estimating precession and nutation quantities is the short timebase of VLBI observations relative to the 18.6-yr nutation period. This leads to high correlations between precession and nutation, and the problem is not expected to be fully removed until the data cover a full 18.6-yr cycle in the late 1990s. The formal uncertainties in Table 6 should be interpreted with these high correlations in mind (the largest correlation coefficient between precession and nutation is 0.93). Nevertheless, there is substantial agreement of these values with comparable theoretical [31,32] and experimental [22,33] estimates. Note that the quoted experimental results use data that partly overlap the data used here. It is stressed that any application using the source coordinates of Table 5 must also model the celestial pole position with the parameters of Table 6.

## V. Consistency Tests and Accuracy Estimates

The database involved in generating the radio source coordinates presented here is too large to permit many internal consistency tests to be carried out within a reasonable time span, with the computing facilities currently available. Therefore, assessment of the validity of the formal  $1\sigma$  statistical parameter uncertainties was performed by comparison of the estimated coordinates with those of a variety of other catalogs, based on data that overlap the present database to varying degrees.

The first category of such catalogs includes those based only on RRFD and TEMPO data. The DSN catalogs JPL 1987-1 [2] and JPL 1991-1 [4] are selected for comparison with JPL 1990-3. Catalog JPL 1987-1 contains positions of 128 sources, and is the last DSN catalog described in an external refereed publication. Note that data entering 1987-1 terminate in late 1985, well before the inception of DSN Mark III systems. Catalog JPL 1991-1 is the current TEMPO catalog, based on RRFD and TEMPO data through early 1991, and thus includes more sources (241) and more than twice the number of RRFD Mark III observations used for 1990-3.

The second category of catalogs includes those determined by other research groups. There are many possible candidates for comparison, of which only three are chosen. One important member of this category is the IERS catalog 90C01 [20], which combines individual CDP, IRIS, USNO, and JPL catalogs, with due attention paid to removal of rotational offsets and evaluation of formal uncertainties from disparate analyses. It contains the coordinates of 228 sources. Two GSFC catalogs were chosen to be representative of other external results. The first, here denoted GSFC89, is from [14]. It is based on 238,000 CDP and IRIS observations through early 1988 and contains 182 sources. A somewhat premature attempt was made to tie these source coordinates to the optical FK5 frame, which accounts for the large (\$\approx 25 \text{ nrad}) rotation in right ascension that is required to make this catalog coincide with any conventional radio catalog. A later Goddard catalog, denoted GSFC90 [15], extends the CDP and IRIS database and adds NAVNET [34] and southern hemisphere astrometric experiments, for a total of 461,000 observations of 318 sources.

Pairwise comparisons were made between the present source catalog and the above five collections of source

positions derived from VLBI data. Prior to comparing the source coordinates, three-dimensional rotational offsets were calculated and removed for each pair in order to account for the different right ascension and nutation reference points used in deriving each catalog. These rotational offsets are a manifestation of the different methods used to define the orientation of the celestial reference frame for each catalog. Tables 7 and 8 give the magnitudes of these rotational offsets (whose uncertainties are of the order of 0.1 nrad), as well as the  $\chi^2$  per degree of freedom  $(\chi^2_{\nu})$  in the least-squares solution determining the rotational transformations. After the rotation is applied (to the catalog other than 1990-3), the right ascension differences are scaled to arc-length differences by applying the factor cos (declination), and then RMS differences are calculated for both source coordinates. Note that all the catalogs involved in the comparisons (with the exception of 1987-1) were generated by fits that corrected the 1980 IAU nutation and precession errors by estimating either daily CEP orientation or nutation amplitudes and the precession constant.

Statistical analysis of uncertainties is problematic in cases like the present, where the same parameters are estimated from partially overlapping data. When this work is extended to include databases through 1991, a more complete statistical assessment will need to be performed. For the present, the covariance matrices for both catalogs are assumed to be diagonal, and the uncertainty of the difference of a given coordinate is assumed to be the root sum square of the individual  $1\sigma$  uncertainties. In previous work, neglecting off-diagonal covariances somewhat underestimated the true errors.

From Table 7, it can be seen that agreement of JPL 1990-3 with the other two JPL catalogs is reasonable, at the level of the formal uncertainties. Rotational offsets are as large as 7 nrad for 1987-1, but much smaller for the more recent 1991-1. This is a manifestation of precession/nutation model deficiencies that were not as well corrected for 1987-1 as in more recent fits. Root-mean-square RA and declination differences are nearly consistent with the uncertainty level of the catalogs (≈10 nrad for 1987-1 and < 5 nrad for 1991-1 and 1990-3). The  $\chi^2_{\nu}(RA)$  values of 2.0 and 1.8 indicate some problem with right ascensions that is not encountered with declinations. In order to test whether the comparisons are being distorted by selection of sources, the two comparisons were repeated, including only sources that have formal  $\sigma$ 's smaller than 5 nrad in both catalogs. Results for rotational offsets and  $\chi^2_{\nu}$ 's are essentially unchanged, and the RMS differences decrease to approximately 4 and 3 nrad for 1987-1 and 1991-1, respectively.

Comparisons with the IERS catalog and two GSFC catalogs in Table 8 paint a more pessimistic picture than the intra-JPL comparisons. Rotational offsets are as large as 10 nrad (the 24-nrad rotation of GSFC89 was already mentioned above), RMS differences are slightly higher than 5 nrad, and  $\chi_{\nu}^2$ 's range from 2 to 4. A 5-nrad cut on input catalog errors decreases the RMS differences slightly but raises the  $\chi^2_{\nu}$ 's even further. This suggests that the formal uncertainties are underestimating true errors due to some systematic effects coming into play at the nanoradian level. When the catalog formal  $\sigma$ 's are root sum squared with 2 nrad for all coordinates of each catalog pair in the comparisons, the  $\chi_{\nu}^2$ 's are reduced to the 0.8-1.4 range; a slightly larger additive error (3 nrad) is required in the IERS90 comparison. Until further work identifies the source of the 2-3-nrad systematic errors, these results place a lower limit on the accuracy achievable in source position determinations. To be investigated are tropospheric covariance, the consequences of UTPM errors, a detailed comparison of modeling and analysis procedures, and proper motion or time-varying source structure. Approximately 100 sources show formal position uncertainties of 2 nrad or smaller in the JPL 1990-3 catalog. Indications are that the low  $\sigma$ 's are solely due to the extremely large number of observations, and do not properly reflect presently unidentified and unmodeled systematic errors.

In conclusion, the addition of several hundred thousand non-DSN VLBI observations to the DSN data set in a fit determining a radio reference frame has the beneficial effects of checking consistency of source coordinates derived from disparate sets of baselines and revealing modeling deficiencies at the 2-nrad level. Considerable improvement is seen in the formal uncertainties (Fig. 1 versus Fig. 2), nearly 50 percent of the 1990-3 uncertainties are brought below the level of presently unidentified systematic effects. A similar level of resolution may not have been reached solely with DSN data for another year or two. It appears that the true accuracy of the JPL 1990-3 catalog is approximately at the 5-nrad level.

#### VI. Conclusions

Source angular coordinates of 216 extragalactic objects are derived from a database that includes the majority of the world's astrometric VLBI measurements through 1990. Care has been taken to eliminate some known sources of systematic error, in particular the inadequacy of the present standard precession/nutation model. The formal uncertainties of these JPL 1990-3 source positions are predominantly smaller than 5 nrad. Consistency tests indicate that the formal errors are overoptimistic, espe-

cially those below 2 to 3 nrad. The 2- to 3-nrad limit appears to be the point at which unknown systematics dominate. In spite of these systematics, comparisons with source coordinates from independent analyses of data that partly overlap the database used here show that the 1990-3 positions agree at approximately the 5-nrad level. This catalog may thus be one of the first to exhibit true 5nrad accuracy. Consistency with the non-DSN data in the analysis, with its greater variety of baseline orientations and lengths, indicates that no serious systematic errors are present in the DSN-only data that might be introduced by the DSN baseline geometry, particularly the extremely long California-Australia baseline. Consistency with GSFC catalogs also provides an indirect verification that there are no outstanding discrepancies between JPL and GSFC modeling and estimation software at the 5-nrad level.

The status of the 1990-3 reference frame relative to future mission requirements remains to be fully characterized. When used with the CEP model of Table 6, the 1990-3 source coordinates are expected to yield accurate source coordinates of date several years into the future. If the true accuracy of this catalog is at the 5-nrad level,

as indicated by the above-mentioned comparisons, then it is very close to satisfying Galileo specifications. The TOPEX/POSEIDON S-/X-band and preliminary Cassini Ka-band (32-GHz) 3-nrad requirements are more difficult to meet; however, many of the errors in constructing a Ka-band reference frame should be the same as those for the present S-/X-band frame. It is expected that further analytical refinements and acquisition of additional VLBI measurements will permit achieving the 3-nrad level within the next few years.

Future data analysis is planned along lines similar to that presented here, incorporating the more recent high-quality DSN Mark III data, as well as updates of the TEMPO, CDP, and IRIS databases. Empirical corrections for two of the known causes of systematic error (source structure and troposphere mismodeling) will be incorporated in future parameter estimates. Including LLR data extending back to 1969 would also be of substantial help in reducing the precession-nutation correlations [33]. Such fits are expected to reduce source coordinate uncertainties further, to better characterize the true accuracies, and to satisfy future navigation requirements for a radio reference frame.

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Table 1. Summary of VLBI observing programs

Program	$N_{stn}$	$N_{bsl}$	Time period	$N_{ses}$	$N_{src}$	$N_{obs}$
CDP	31	144	79/8 - 89/12	178	76	134,627
IRIS	8	24	84/1 - 90/6	452	31	168,119
TEMPO	3*	3*	80/7 - 90/9	665	106	7,324
RRFD MkII	3*	2*	78/10 -89/ 4	65	230	8,520
RRFD MkIII	3*	2*	88/8 - 90/7	13	214	1,144
Total	34	147	78/10 - 90/ 9	1373	230	319,734

<sup>\*</sup>DSN Deep Space Communications Complex

Table 2. Noise characteristics of VLBI data

Program	$N_{obs}$	RMS data noise, psec	RMS added
CDP	134,627	100	77
IRIS	168,119	94	66
TEMPO	7,324	464	260
RRFD MkII	8,520	395	158
RRFD MkIII	1,144	65	50

Table 3. Elevation-angle distributions of VLBI data

Program	$f_{10}$	$f_{20}$	f <sub>30</sub>
CDP	0.020	0.129	0.278
IRIS	0.023	0.111	0.218
TEMPO	0.066	0.310	0.548
RRFD	0.065	0.293	0.510

Table 4. RMS delay and rate residuals of VLBI data

Program	Delay, psec	Delay rate, fsec/sec
CDP	96	113
IRIS	86	81
TEMPO	448	109
RRFD MkII	336	134
RRFD MkIII	87	117
All	123	100

Table 5. Source coordinates from combined VLBI measurements, 1978-90

	Common name	Mean observation	Number of			,	Error,				Error,	KA, dec.
		epoch	observations	별	min	sec	msec	₽	E	asec	mas	correlation
0008-264	P 0008-264	1984.667	38	0	11	1.246868	0.071	-26	12	33.37761	0.81	-0.933
0013-005	P 0013-00	1989.589	œ	0	16	11.088443	0.151	0-	15	12.44239	2.25	-0.989
0016+731	0016+731	1988.839	33	0	19	45.785908	0.131	73	27	30.01964	0.39	0.102
0019 + 058	P 0019+058	1984.773	50	0	22	32.441219	0.026	9	œ	4.26917	0.77	-0.570
0048-097	P 0048-09	1989.463	344	0	20	41.317356	0.007	6-	29	5.20976	0.12	-0.195
0104 - 408	P 0104-408	1985.701	86	-	9	45.108147	090.0	-40	34	19.95992	0.45	-0.875
0106+013	P 0106+01	1986.699	12430	1	œ	38.771065	0.002	1	35	0.31787	90.0	-0.088
0111+021	P 0111+021	1983.353	37	_	13	43.145073	0.098	7	22	17.31556	1.58	-0.913
0112-017	P 0112-017	1988.929	24	1	15	17.099895	0.015	-1	27	4.57657	0.29	-0.779
0113-118	P 0113-118	1984.385	19	1	16	12.521992	0.035	-11	36	15.43412	0.52	-0.902
0119+115	P 0119+11	1988.888	22	1	21	41.595005	0.015	11	49	50.41420	0.32	-0.761
0119+041	GC 0119+04	1990.096	1023	1	21	56.861675	0.004	4	22	24.73470	0.15	-0.252
0133+476	DA 55	1984.855	172	1	36	58.594818	0.010	47	51	29.10011	0.25	-0.365
0146+056	0146+056	1988.710	14	1	49	22.370842	0.033	5	55	53.57026	0.61	-0.859
0149+218	P 0149+21	1989.085	∞	-	25	18.059040	0.048	22	~	7.70014	0.77	-0.815
0201+113	P 0201+113	1987.110	15	2	3	46.657017	0.025	11	34	45.41072	0.56	-0.748
0202 + 149	P 0202+14	1985.729	123	2	4	50.413879	0.008	15	14	11.04385	0.15	-0.701
0208 - 512	P 0208-512	1988.393	3	2	10	46.199532	0.271	-51	-	1.88993	1.83	-0.886
0212+735	0212+735	1987.203	20017	2	17	30.813374	0.009	73	49	32.62226	0.03	-0.437
0221 + 067	GC 0221+06	1988.948	12	2	24	28.428144	0.027	9	29	23.34205	0.38	-0.900
0224 + 671	DW 0224+67	1981.836	898	2	28	50.051556	0.014	29	21	3.02982	0.10	-0.386
0229+131	P 0229+13	1987.214	11202	2	31	45.894047	0.002	13	22	54.71671	0.04	-0.164
0234 + 285	CTD 20	1987.195	6544	3	37	52.405674	0.003	(28	48	8.99038)	(0.00)	(0.000)
0235 + 164	GC 0235+16	1982.164	903	2	38	38.930103	9000	16	36	59.27496	0.11	999:0-
0239 + 108	OD 166	1985.359	92	2	42	29.170900	0.030	111	-	0.72751	0.37	-0.931
0250+178	GC 0250+17	1989.677	12	5	53	34.882183	0.037	18	2	42.52564	1.05	-0.566
0256+075	OD 094.7	1983.652	32	8	59	27.076651	0.036	7	47	39.64091	1.83	-0.399
0300+470	OE 400	1988.855	3466	3	8	35.242237	0.004	47	16	16.27578	0.04	-0.306
0306 + 102	0306 + 102	1989.282	14	3	6	3.623471	0.028	10	29	16.34191	0.42	-0.895
0309 + 411	0309+411	1987.721	12	33	13	1.962166	0.035	41	20	1.18315	1.01	-0.157
0316 + 413	3C 84	1984.601	308	3	19	48.160145	0.010	41	30	42.10449	0.18	-0.044
0317 + 188	P 0317+188	1989.671	11	ဂ	19	51.256706	0.012	19	-	31.29180	0.32	-0.646
0326+277	0326+277	1988.134	10	3	53	57.669388	0.041	27	56	15.49998	0.53	-0.671
0332 - 403	P 0332-403	1983.633	49	8	34	13.654550	0.111	-40	œ	25.39683	0.81	-0.882
0333+321	NRAO 140	1983.205	123	ဇ	98	30.107639	0.029	32	18	29.34300	0.30	-0.838
0336-019	CTA 26	1985.726	68	m	36	30 937748	0.011	ī	46	35 80241	0	

Table 5 (contd)

IAU name	Common name	Mean observation	Number of	H	light as	Right ascension	Error,		Declination	ation	Error,	RA, dec.
		eboch	observations	궏	min	sec	msec	P	E	asec	mas	correlation
0342+147	0342+147	1987.811	28	3	45	6.416506	0.034	14	53	49.55854	0.46	-0.821
0355+508	NRAO 150	1982.000	1847	က	29	29.747309	0.007	20	22	50.16193	0.02	-0.238
0400 + 258	CTD 26	1987.340	3	4	က	5.586178	0.180	56	0	1.50284	1.83	-0.973
0402 - 362	P 0402-362	1985.129	104	4	က	53.749821	0.038	-36	2	1.91249	0.41	-0.915
0406 - 127	0406 - 127	1989.466	4	4	6	5.769566	0.151	-12	38	48.14061	2.13	-0.983
0406 + 121	GC 0406+12	1984.235	96	4	6	22.008692	0.027	12	17	39.84791	0.42	-0.766
0409+229	P 0409+22	1989.663	13	4	12	43.666847	0.016	23	5	5.45394	0.36	-0.545
0420 - 014	P 0420-01	1988.604	6728	4	23	15.800686	0.002	-1	20	33.06435	0.05	-0.254
0420+417	VRO 41.04.01	1980.724	11	4	23	56.009869	0.202	41	20	2.71570	2.89	-0.458
0423 + 233	GC 0423+23	1989.671	111	4	56	55.734795	0.011	23	27	39.63453	0.31	-0.565
0425 + 048	P 0425+048	1987.655	26	4	27	47.570328	0.104	4	22	8.32905	1.47	-0.977
0426+273	0426+273	1989.666	14	4	29	52.960754	0.013	27	24	37.87780	0.42	-0.472
0430 + 052	3C 120	1981.230	141	4	33	11.095490	0.023	5	21	15.62231	0.77	-0.558
0434 - 188	P 0434-188	1985.211	100	4	37	1.482675	0.017	-18	44	48.61311	0.29	-0.715
0438-436	P 0438-43	1982.778	40	4	40	17.179842	0.116	-43	ಜ	8.60147	0.78	-0.864
0440+345	0440+345	1989.178	13	4	43	31.635271	0.035	34	41	6.66321	0.41	-0.772
0446+112	P 0446+11	1989.025	20	4	49	7.671068	0.027	11	21	28.59826	0.48	-0.745
0451 - 282	P 0451-28	1983.885	18	4	53	14.646607	960.0	-28		37.32491	1.17	-0.962
0454 - 234	0454 - 234	1990.200	613	4	57	3.179160	900.0	-23	24	52.01993	0.26	-0.326
0458+138	P 0458+138	1989.351	10	ro	1	45.270744	0.106	13	26	7.22257	1.38	-0.968
0459+060	GC 0459+06	1989.592	<b>∞</b>	S	7	15.445878	0.139	9	6	7.49573	2.01	-0.984
0500+019	0500+019	1988.822	12	ro	က	21.197086	0.034	7	က	4.67747	0.51	-0.911
0502+049	P 0502+049	1989.433	111	2	ro	23.184755	0.094	4	29	42.72493	1.29	-0.987
0454+844	0454+844	1986.115	29	2	∞	42.363876	0.121	84	32	4.54414	0.21	0.019
0506+101	P 0506+101	1988.770	20	2	6	27.457073	0.027	10	11	44.60062	0.42	-0.888
0507+179	P 0507+17	1987.671	25	S	10	2.369150	0.028	18	0	41.58187	0.43	-0.704
0511 - 220	P 0511-220	1989,307	9	ĸ	13	49.114277	0.032	-21	29	16.09140	0.59	-0.794
0528+134	P 0528+134	1987.290	12691	5	30	56.416737	0.001	13	31	55.15025	0.04	-0.400
0537 - 441	P 0537-441	1985.159	134	2	88	50.361164	0.074	-44	ις	8.93651	0.59	-0.912
0537 - 158	P 0537-158	1988.071	ဗ	22	33	32.010201	0.067	-15	20	30.32208	3.36	-0.395
0536 + 145	0536+145	1988.410	28	2	33	42.366028	0.025	14	33	45.56190	98.0	-0.911
0544+273	0544+273	1987.942	17	2	47	34.148983	0.046	27	21	56.84298	0.73	-0.700
0552+398	DA 193	1986.888	25513	2	55	30.805620	0.002	39	48	49.16539	0.03	-0.395
0556+238	0556+238	1988.579	31	2	59	32.033134	0.014	23	53	53.92704	0.27	-0.553
0600+177	0600+177	1988.235	28	9	က	9.130286	0.029	17	42	16.81109	0.40	-0.913
0605-085	P 0605-08	1981.668	12	9	7	59.699158	0.105	8	34	49.97785	2.02	-0.766
									İ			

Table 5 (contd)

Control Rotation	1111		Mean observation	Number of	Ri	ght asc	Right ascension	Error,		Declination	ation	Error,	RA, dec.
OCIII+131         1988-663         5         6         13         57-692436         0.031         13         6         45-409639         0.031         13         6         45-409639         0.031         13         6         45-409639         0.031         13         6         45-409639         0.031         13         6         45-409639         0.031         13         6         45-409639         0.031         13         6         45-409639         0.031         13         6         96-77-14         13         98-8048         0.031         13         7         2         14-09639         0.041         -0         6         15-10-146         0.031         14         25         13-10-146         0.031         14         25         13-10-146         0.031         14         25         13-10-146         0.031         14         25         14-09639         0.041         -0         6         15-10-146         0.031         14         15         25         14-09639         0.041         -0         6         15-10-146         0.031         14         15         0         14-09639         0.041         -0         6         15-10-146         0.031         14         25         13-10-146	IAU name	Common name	epoch	observations		min	sec	msec	ъ	Ħ	asec	mas	correlation
3C 166         1988.667         15         6         45         24,089.539         0.031         21         12         12,120.09         0.48           PONT22+147         1985.043         198.7192         12         7         10         12,585.73         1         1         2         1,125.637         1         1         2         1,125.637         1         1         2         1,125.637         1         1         2         1,125.637         1         1         2         1,125.637         1         1         2         1,125.637         1         1         2         1,125.630         0.04         1         1         2         1,125.637         0.04         1         1         2         1,125.637         0.04         1         1         2         1,125.637         0.04         1         1         1         2         1,125.637         0.04         1         1         2         1         2         1 <td>0611+131</td> <td>0611+131</td> <td>1989.633</td> <td>5</td> <td>9</td> <td>13</td> <td>57.692436</td> <td>0.210</td> <td>13</td> <td>9</td> <td>45.40760</td> <td>2.82</td> <td>-0.989</td>	0611+131	0611+131	1989.633	5	9	13	57.692436	0.210	13	9	45.40760	2.82	-0.989
OSST-172         1987-192         23         7         0         1.555573         0.043         17         9         17-10-193         0.80           OP 07224-446         1988-2003         19         7         25         16.507871         0.047         14         25         13.74644         0.20           DW 07224-10         1988-2078         2111         7         25         16.507871         0.07         14         25         13.74644         0.73           P 0727-11         1988-2078         2111         7         26         19.114456         0.003         -11         41         12.0000         0.77           P 0727-11         1988-2078         211         7         28         15.00727         14         17         41         10.700863         0.001         -1         41         12.0000         0.77         -1           O 1933-10         1988-2078         104         7         41         10.700863         0.001         1         41         42         45.811         0.01         2.2           O 1933-10         10         10         7         41         10.700863         0.001         1         41         41.81849         0.71	0642+214	3C 166	1988.667	15	9	45	24.099539	0.031	21	21	51.20209	0.48	-0.783
POT72+145         1989-203         19         7         25         16.807827         0.007         14         25         13.4444         0.39           POT72+145         1988-378         19         7         25         16.807827         0.001         -0         56.54468         0.71           POT73-10         1988-378         2111         7         21         21.000         0.01         -0         45         56.5468         0.01           POT73-17         1988-378         211         7         28         17.000         17         42         18.9918         0.01           OL 783-17         1984-07         104         7         48         17.000         17         42         18.8918         0.01           OL 783-17         1984-07         104         7         48         35.005821         0.00         17         41         17.0008         0.00         17         41         18.8918         0.01	0657+172	0657+172	1987.192	23	7	0	1.525573	0.043	17	6	21.70139	0.80	-0.805
DW 0722-00         1985.649         82         7         25         50.639098         0.011         -0         54         56.4408         0.77           P 0727-17         1885.748         2111         7         39         19112456         0.003         11         4         12.56000         0.77           P 0724-17         1885.748         8         27         7         39         18.273884         0.003         17         4         12.56000         0.07           P 0724-17         1885.448         8         1         2         2         18.23884         0.013         0.21         0.21         0.21         0.21         0.009         17         4         17.28977         0.009         17         4         17.28977         0.009         17         4         17.28978         0.009         0.21         0.21         0.21         0.009         0.21         0.21         0.21         0.21         0.21         0.21         0.22         0.22         0.009         17         4         2.284182         0.023         0.21         0.21         0.009         17         4         2.284182         0.023         0.21         0.22         0.009         17         4         2.284182	0722+145	P 0722+145	1989.203	19	7	25	16.807827	0.027	14	22	13.74644	0.39	-0.916
POT27-11         1988.978         2111         7         30         19.11445         0.003         -11         41         15.0000         0.07           POT37+17         1988.148         82         7         38         13.33737         0.003         -11         4         18.99918         0.01           OF 073+17         1985.148         82         7         38         18.03384         0.015         1         4         4.1811         0.26           OF 0734-2         1985.049         17         4         10.70563         0.004         11         1         2.25         4         0.275418         0.004         11         1         0.26         0.54         0.004         11         1         0.26         0.54         0.003         1.1         1         0.26         0.54         0.003         1         2         4.61811         0.02         0.54         0.54         0.003         0.003         0.54         0.003         0.004         0.014         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004         0.004	0723-008	DW 0723-00	1983.649	82	2	25	50.639908	0.041	0-	54	56.54408	0.71	-0.889
POT35+17         1985.148         82         7         38         7.3837.37         0.009         17         42         18.99918         0.21           OL 353-0.1         186,077         16         7         41         10.702663         0.015         17         4.41811         0.256           OL 363-0         198,077         17         41         10.702663         0.001         11         12.2068         0.54           DW 0742+10         1985,049         50         7         46         25.87432         0.002         21         0.12         1.52           BQ 0744+13         1985,049         50         7         46         25.87432         0.002         21         9.21490         0.55           P 0744+136         1985,049         50         7         46         25.87432         0.002         21         4.21114         0.55         0.14114         0.002         0.01         1         1.428637         0.55         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002         0.002<	0727-115	P 0727-11	1988.978	2111	7	30	19.112436	0.003	- 11	41	12.60000	0.07	-0.306
P 07736+01         1989,776         16         7         39         18033834         1         37         461811         0.26           O1 353         1984,907         17         7         45         10,70363         0.002         31         12,6277         0.13           O1 353         1984,907         17         7         45         25,874182         0.002         31         1         2.26588         0.03           OC 0744+25         1988,318         15         7         46         25,874182         0.002         35         49         2.13490         0.32           D 0744+100         1989,022         14         7         5         45,610373         0.031         24         8         12,535896         0.018         7         48         36,10373         0.03         12         2.13490         0.52           P 0744+100         1980,022         14         7         5         6,612364         0.03         3         4,482833         0.57           P 0825-04         1886,049         28         7         48         15,53889         0.043         3         4,483843         0.03         12         4,483843         0.03         14         4,483843	0735+178	P 0735+17	1985.148	82	2	38	7.393737	600.0	17	42	18.99918	0.21	-0.686
O1 363         1984.907         17         7         41         17.00963         0.02         31         12.568277         0.54           DW 0743+10         1987.855         1044         7         46         3.0095821         0.004         10         1         12.56927         0.54           GC 0743+24         1988.918         50         7         48         8.6109272         0.031         24         9         1.14         0         24.11141         0.65           BZ 0745+24         1988.923         68         7         50         2.049738         0.030         12         31         4.28833         0.57           P 0745+100         1988.022         8         7         50         2.049738         0.03         12         31         4.88173         0.57           OJ 45         1986.800         294         8         15.53586         0.14         47         2         14.11141         0.65           D 404.90         1986.800         294         8         15.53586         0.14         42         2         13.1141         0.65           D 404.90         1986.800         294         8         15         50.38837         0.06         3	0736+017	P 0736+01	1989.726	16	7	33	18.033884	0.015	1	37	4.61811	0.26	-0.892
DW 0742+10         1987.855         1044         7         45         3.0.0892.1         0.004         10         1         1.2.2692.7         0.12           GC 0744+2         1988.918         15         7         46         2.874182         0.032         25         49         2.13490         0.52           B 2 0745+24         1988.049         5         6         7         46         2.874182         0.032         25         49         2.13490         0.55           P 0744+106         1988.022         14         7         5         6.610972         25         9         5.411114         0.65           P 0805-07         1987.825         8         8         15         15.99685         0.148         7         5         6.42054         0.028         9         5         4.411141         0.55         3         1.418         7         5         6.42054         0.028         9         5         4.411141         0.55         3         1.418         7         5         6.42054         0.028         9         5         4.411141         0.55         3         1.418         1.539685         0.148         9         1.4187492         0.148         0.148         0.148 <td>0738+313</td> <td>OI 363</td> <td>1984.907</td> <td>17</td> <td>-1</td> <td>41</td> <td>10.703663</td> <td>0.062</td> <td>31</td> <td>12</td> <td>0.22568</td> <td>0.54</td> <td>-0.977</td>	0738+313	OI 363	1984.907	17	-1	41	10.703663	0.062	31	12	0.22568	0.54	-0.977
B2 0743+23         1988 918         15         7         46         25.874182         0.022         25         49         21.31490         0.52           B2 0745+24         1985 049         80         7         48         61,09272         0.031         24         9         5         21,11141         0.65           P 0745+126         1985 049         8         7         7         5         2.040772         0.031         21         3         9         1371141         0.67           P 0754+106         1985 022         14         7         7         5         2.040772         0.031         2         0.37         0.57         0.030         0.04         0.03         0.04         0.03         0.04         0.03         0.04         0.04         0.03         0.04	0742+103	DW 0742+10	1987.855	1044	2	45	33.059521	0.004	10	Ξ	12.69277	0.12	-0.463
B2 0745+24         1985.049         50         7         48         56.109272         0.031         24         0         24.1141         0.65           P 0748+126         1985.493         68         7         50         52.04778         0.030         12         31         4.82853         0.57           P 0774+110         1986.902         14         7         50         52.04778         0.030         12         31         4.82853         0.57           P 0805-07         1987.825         8         8         15.996.86         0.048         9         5         34.8177         2.29         9         5         34.8177         0.09         9         5         45.84877         0.014         42         22         45.1528         0.18         9         0.148         4         5         50.38377         0.00         9         2         45.04889         0.00         1         9         1.590865         0.014         42         22         45.1528         0.18         1         45.90866         0.014         42         22         45.1528         0.18         1         45.28897         0.014         42         22         45.1528         0.18         1         45.28897	0743+259	GC 0743+25	1988.918	15	7	46	25.874182	0.032	25	49	2.13490	0.52	-0.708
P 0744+126         1983-493         68         7         50         22045736         0.030         12         31         4.82853         0.57           P 0744+100         1989-022         14         7         57         6.642964         0.028         9         6.42964         0.028         9         6.43964         0.028         9         6.441728         0.57           O 1 425         1986-800         25         18         15.53896         0.014         -7         5         4.541728         0.58           O 1 425         1986-800         25         25         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.014         -7         5         4.54966         0.048         -8         4.54966         0.049         -9         4.54969         0.059         -7	0745+241	B2 0745+24	1985.049	50	2	48	36.109272	0.031	24	0	24.11141	0.65	-0.553
P 0754+100         1989 022         14         7         57         6.42954         0.028         9         56         34.81772         0.50           P 0805-07         1987 825         8         8         8         15.338896         0.148         -7         51         9.84773         2.29           OJ 425         1987.175         25         8         18.538896         0.148         -7         51         9.82732         0.00           P 0823+033         1986.860         294         8         8         18.538895         0.014         42         2         4.515204         0.13           B 0 0237+24         1986.860         294         8         3         5.0388357         0.006         3         4.515204         0.13           4C 71.07         1986.910         294         8         41         24.368891         0.25         4.51         1.52047         0.13           OJ 287         1986.910         20         2         4.8874200         0.000         2         4.513771         1.60           OJ 499         1986.910         3         4.8874200         0.000         2         4.513771         1.61           OJ 490         1986.61 <t< td=""><td>0748+126</td><td>P 0748+126</td><td>1983.493</td><td>89</td><td>7</td><td>20</td><td>52.045738</td><td>0.030</td><td>12</td><td>31</td><td>4.82853</td><td>0.57</td><td>-0.740</td></t<>	0748+126	P 0748+126	1983.493	89	7	20	52.045738	0.030	12	31	4.82853	0.57	-0.740
P 0805—07         1987.825         8         8         15.538896         0.148         -7         51         9.884.73         2.29           OJ 425         1987.175         257         8         18         15.538896         0.144         -7         51         9.884.73         2.29           OJ 425         1986.860         254         8         25         50.33837         0.004         4         2         45.45128         0.18           B2 0827+24         1986.860         17         8         25         50.33837         0.006         2         4         6.148         9         2.2086189         0.004         2         45.45177         0.138         0.005         2         45.45177         0.138         0.004         0	0754+100	P 0754+100	1989.022	14	۲-	22	6.642954	0.028	6	26	34.85172	0.50	-0.803
OJ 425         1987.175         257         8         15.999555         0.014         42         25         45.41528         0.18           P 0823+033         1986.880         294         8         25         50.33837         0.006         3         9         41.52047         0.13           B 2 0837+24         1986.880         294         8         25         50.33837         0.006         3         9         4.15.044         0.13           AC 71.07         1980.827         17         8         3         5.208189         0.055         7         53         42.15749         0.13           OJ 287         40 1384.806         17         8         4         4.874590         0.005         2         5         4.171749         0.13           OJ 489         1984.806         34         9         2         16.831095         0.129         -14         15         30.87777         1.60           OJ 489         1984.806         34         9         2         16.831095         0.129         -14         15         30.87777         1.60           OJ 489         1985.053         16         9         2         16.417778         0.14         33.838777	0805-077	P 0805-07	1987.825	00	8	<b>∞</b>	15.535896	0.148		51	9.88473	2.29	-0.998
P 0823+033         1986.860         294         8         25         50.338337         0.006         3         9         24.52047         0.13           B2 0827+24         1983.847         17         8         20         52.086189         0.035         24         10         59.82098         0.46           4C 71.07         1981.082         17         8         41         24.36801         0.035         24         10         59.82098         0.46           OJ 287         1984.361         2063         8         41         24.36801         0.22         70         53         42.17249         0.16           OJ 287         1984.90         1984.301         19         3         198.874920         0.020         20         6         9         14.8374920         0.020         20         6         0.04         1         4.17749         0.04         2         0.64131         0.04         2         0.64131         0.04         2         0.641777         0.04         2         0.641777         0.14         4.13771         1.60           OD 192-203         1986.312         1         2.2 46.41777         0.02         2         2         1.24.32427         0.04         2 <td>0814+425</td> <td>OJ 425</td> <td>1987.175</td> <td>257</td> <td>œ</td> <td>18</td> <td>15.999655</td> <td>0.014</td> <td>42</td> <td>22</td> <td>45.41528</td> <td>0.18</td> <td>-0.365</td>	0814+425	OJ 425	1987.175	257	œ	18	15.999655	0.014	42	22	45.41528	0.18	-0.365
B2 0827+24         1983.847         17         8         30         52.086189         0.035         24         10         59.82098         0.46           4C 7.107         1981.082         17         8         41         24.36801         0.252         70         53         42.17249         1.67           OJ 287         1986.910         20630         8         4         48.874920         (0.000)         20         6         30.64131         (0.00)           P 0829-14         1984.361         3         2         16.831095         0.129         -14         15         30.87131         1.60           P 0829-14         1984.306         34         3         3990097         0.088         46         31         41.37771         1.60           P 0912-203         1985.027         16         3         3         3990097         0.044         2         4         35.34017         1.43         3.74           P 0920-29         1986.915         2         2         16.417778         0.044         2         4         45.354017         1.74         15         30.447         2.14           Q 020.25-203         1986.915         11         3         2         16.41	0823+033	P 0823+033	1986.860	294	œ	25	50.338337	0.006	3	6	24.52047	0.13	-0.636
4C 71.07         1981.082         17         8         41         24.365801         0.252         70         53         42.17249         1.67           OJ 287         1986.910         20630         (8         54         4.874920         (0.000)         (20         6         30.64131         0.00           P 0859-14         1984.361         19         2         16.831095         0.129         -14         15         30.4131         0.00           OJ 499         1984.806         34         9         2         16.831095         0.129         -14         15         30.84777         1.60           OJ 499         1984.806         34         3.990097         0.068         46         51         41.13771         1.85           P 0912-200         1988.073         16         9         21         2.934017         0.149         -2         46.33887         3.74         1.85           P 0925-203         1986.915         23         2         4.447778         0.149         -2         1.853792         0.169         -2         1.4480988         0.169         -2         1.848747         0.149         3.74         1.14           OK 290         1980.325         1980.326<	0827+243	B2 0827+24	1983.847	17	<b>∞</b>	30	52.086189	0.035	24	10	59.82098	0.46	-0.943
OJ 287         1986.910         20630         (8         54         48.874920         (0.000)         (20         6         30.64131         (0.00)           P 0859-14         1984.361         19         2         16.831095         0.129         -14         15         30.87777         1.60           OJ 499         1984.806         34         3         3.990097         0.068         46         51         4.13771         1.85           P 0912+029         1989.603         16         9         2         16.831095         0.044         2         46         51         4.13771         1.85           P 0912-260         1989.603         16         9         2         46.417778         0.046         2         43.33887         3.74         1.85           P 0925-203         1986.915         23         2         46.417778         0.026         29         2         24.417778         0.129         2         20.85175         3.74           P 0925-203         1986.915         2         2         46.417778         0.026         29         2         20.85172         3.74           OK 290         1986.571         8         9         5         46.417778 <t< td=""><td>0836+710</td><td>4C 71.07</td><td>1981.082</td><td>17</td><td>œ</td><td>41</td><td>24.365801</td><td>0.252</td><td>70</td><td>53</td><td>42.17249</td><td>1.67</td><td>0.161</td></t<>	0836+710	4C 71.07	1981.082	17	œ	41	24.365801	0.252	70	53	42.17249	1.67	0.161
P 0859—14         1984.361         19         2         16.831095         0.129         -14         15         30.87777         1.60           0J 499         1984.806         34         9         3         3.990097         0.068         46         51         4.13771         1.85           P 0912-020         1989.603         16         9         21         29.354017         0.04         2         45         59.24608         0.68           P 0912-200         1989.603         16         9         21         29.354017         0.04         2         45         59.24608         0.68           P 0920-39         1986.915         23         2         46.41778         0.04         2         43.3887         37.4         1.85           Q 0925-203         1986.915         23         2         46.41778         0.06         -39         2         20.85215         0.03           Q K 290         1980.571         8         9         2         4.430958         0.16         -2         4.41778         0.06         -3         4.512625         2.19           Q K 290         1980.571         8         9         2         4.4309582         0.16         2	0851+202	OJ 287	1986.910	20630	8)	54	48.874920)	(0.000)	(20	9	30.64131)	(0.00)	(0.000)
OJ 499         1984.806         34         9         3.990097         0.068         46         51         4.13771         1.85           P 0912+029         1989.279         14         37.913448         0.044         2         45         59.24608         0.68           0919-260         1989.603         16         9         21         29.354017         0.149         -26         18         43.3887         3.74           P 0920-39         1987.932         6         9         27         46.417778         0.206         -29         18         43.3887         3.74           4C 39.25         1986.915         23656         9         27         46.417778         0.206         -29         59         35.06447         2.14           4C 39.25         1986.915         21         2.935401         0.026         -29         2         20.85215         0.03           OK 290         1982.027         8         9         5         44.80582         0.166         -2         16.44777         0.018         2         20.85215         0.39           OK 290         1983.032         8         10         1         47.065491         0.029         2         16.49907 <td< td=""><td>0859-140</td><td>P 0859-14</td><td>1984.361</td><td>19</td><td>6</td><td>7</td><td>16.831095</td><td>0.129</td><td>-14</td><td>15</td><td>30.87777</td><td>1.60</td><td>-0.971</td></td<>	0859-140	P 0859-14	1984.361	19	6	7	16.831095	0.129	-14	15	30.87777	1.60	-0.971
P 0912+029         1989.279         14         9         14         37.913448         0.044         2         45         59.2460B         0.68           0919-260         1989.603         16         9         21         29.354017         0.149         -26         18         43.3887         3.74           P 0920-29         1987.932         6         9         22         46.417778         0.26         -39         59         35.06447         2.14           AC 39.25         1986.915         23656         9         27         3.013901         0.002         -39         59         35.06447         2.14           P 0925-203         1986.915         23656         9         27         3.013901         0.002         -39         50.085215         0.03           OK 290         1980.571         86         9         27         51.823792         0.160         -20         34         51.2625         2.19           OK 290         1980.571         86         9         56         49.875427         0.018         25         16.04907         0.03           GC 1022+19         1989.033         53         10         24         47.065491         0.026         19         <	0859+470	01 499	1984.806	34	6	က	3.990097	0.068	46	51	4.13771	1.85	-0.237
919—260         1989 603         16         9         21         29.354017         0.149         -26         18         43.38887         3.74           P 0920-39         1987.932         6         9         22         46.417778         0.206         -29         59         30.6447         2.14           4C 39.25         1986.915         23656         9         27         3.013901         0.002         39         2         20.823792         0.160         -20         34         51.20625         2.19           OK 290         1980.571         86         9         27         51.823792         0.160         -20         34         51.20625         2.19           OK 290         1980.571         86         9         27         51.823792         0.168         25         1.09         27         51.823792         0.18         1.16         1.16         1.16         47.065491         0.029         2         1.19         1.16         1.16         47.065491         0.029         2         1.16         1.16         1.16         47.065491         0.029         2         1.16         0.029         0.029         1.16         1.16         1.16         1.16         1.16         1.16 <td>0912+029</td> <td>P 0912+029</td> <td>1989.279</td> <td>14</td> <td>6</td> <td>14</td> <td>37.913448</td> <td>0.044</td> <td>2</td> <td>45</td> <td>59.24608</td> <td>0.68</td> <td>-0.975</td>	0912+029	P 0912+029	1989.279	14	6	14	37.913448	0.044	2	45	59.24608	0.68	-0.975
P 0920—39         1987.932         6         9         22         46.417778         0.206         —39         59         55.06447         2.14           4C 39.25         1986.915         23656         9         27         3.013901         0.002         39         2         20.85215         0.03           P 0925—203         1987.866         11         9         27         51.823792         0.160         —20         34         51.22625         2.19           OK 290         1980.571         8         9         56         49.875427         0.018         25         15         16.04907         0.03           OK 290         1989.027         20         10         14         47.065491         0.018         25         15         16.04907         0.03           GC 1022+19         1989.027         8         10         24         44.809582         0.026         23         1         16.57087         0.39           P 1034-293         1989.093         53         10         41         17.162470         0.029         29         34         28.1403         0.14           P 1044+719         1988.195         12         1         44         55.911251         0.0	0919-260	0919-260	1989.603	16	6	21	29.354017	0.149	- 26	18	43.38887	3.74	-0.920
4C 39.25         1986.915         23656         9         7         3.013901         0.002         39         2         20.85215         0.03           P 0925-203         1987.866         11         9         27         51.823792         0.160         -20         34         51.22625         2.19           OK 290         1980.571         86         9         56         49.875427         0.018         25         15         16.04907         0.60           1012+232         1989.027         20         10         14         47.065491         0.028         23         1         16.04907         0.60           GC 1022+19         1989.033         8         10         24         44.809582         0.026         19         16.57087         0.03         0.53         0.53           P 1034-293         1984.281         64         10         41         17.162470         0.029         29         34         2.81403         0.14           P 1042+071         1988.317         11         10         44         55.911251         0.036         6         53         38.26318         0.66           P 1055+01         1988.883         2635         10         48         2	0920—397	P 0920-39	1987.932	9	6	22	46.417778	0.206	-39	29	35.06447	2.14	-0.976
P 0925-203         1987.866         11         9         27         51.823792         0.160         -20         34         51.22625         2.19           OK 290         1980.571         86         9         56         49.875427         0.018         25         15         16.04907         0.60           1012+232         1989.027         20         10         14         47.065491         0.029         23         1         16.04907         0.60           GC 1022+19         1989.033         535         10         24         44.809582         0.026         19         12         20.41663         0.39           DL 064.5         1989.093         535         10         37         16.079710         0.009         -29         34         2.81403         0.14           DL 064.5         1984.281         64         10         41         17.162470         0.026         6         16         16.92338         0.72           P 1042+071         1989.195         12         44         55.911251         0.036         6         53         38.26318         0.66           P 1055+01         1988.883         2635         10         48         27.61991         0.017	0923+392	4C 39.25	1986.915	23656	6	27	3.013901	0.002	39	2	20.85215	0.03	0.010
OK 290         1980.571         86         9         56         49.875427         0.018         25         15         16.04907         0.60           1012+232         1989.027         20         10         14         47.065491         0.029         23         1         16.04907         0.60           GC 1022+19         1989.027         8         10         24         44.809582         0.026         19         12         20.41663         0.53           P 1034-293         1989.093         535         10         37         16.079710         0.009         -29         34         2.81403         0.14           OL 064.5         1984.281         64         10         41         17.162470         0.029         -29         34         2.81403         0.14           P 1042+071         1989.195         12         10         44         55.911251         0.036         6         55         38.26318         0.66           P 1044+719         1988.883         2635         10         48         27.619911         0.117         71         43         35.93801         0.66           P 1055+01         1987.230         13         1         7.62063         0.07	0925-203	P 0925-203	1987.866	11	6	22	51.823792	0.160	- 20	34	51.22625	2.19	-0.993
1012+32         1989.027         20         10         14         47.065491         0.029         23         1         16.57087         0.39           GC 1022+19         1989.603         8         10         24         44.809582         0.026         19         12         20.41663         0.53           P 1034-293         1989.093         535         10         37         16.079710         0.009         -29         34         2.81403         0.14           OL 064.5         1984.281         64         10         41         17.162470         0.027         6         10         16.9238         0.14           P 1042+071         1989.195         12         10         44         55.911251         0.036         6         55         38.26318         0.66           P 1044+719         1988.337         11         10         48         27.619911         0.117         71         43         35.93801         0.66           P 1055+01         1988.883         2635         10         58         29.605196         0.002         1         33         58.82394         0.08           P 1104-445         1987.230         13         1         76.063         9 <td< td=""><td>0953+254</td><td>OK 290</td><td>1980.571</td><td>86</td><td>6</td><td>26</td><td>49.875427</td><td>0.018</td><td>25</td><td>12</td><td>16.04907</td><td>09.0</td><td>-0.725</td></td<>	0953+254	OK 290	1980.571	86	6	26	49.875427	0.018	25	12	16.04907	09.0	-0.725
GC 1022+19         1989.603         8         10         24         44.809582         0.026         19         12         20.41663         0.53           P 1034-293         1989.093         535         10         37         16.079710         0.009         -29         34         2.81403         0.14           OL 064.5         1984.281         64         10         41         17.162470         0.027         6         10         16.92338         0.72           P 1042+071         1989.195         12         10         44         55.911251         0.036         6         55         38.26318         0.66           P 1044+719         1988.883         2635         10         48         27.619911         0.117         71         43         35.93801         0.66           P 1055+01         1988.883         2635         10         58         29.605196         0.002         1         33         58.82394         0.08           P 1104-445         1987.230         132         11         7         8.694243         0.083         -44         49         7.62063         0.49	1012+232	1012+232	1989.027	20	10	14	47.065491	0.029	23	1	16.57087	0.39	-0.959
P 1034–293         1989.093         535         10         37         16.079710         0.009         -29         34         2.81403         0.14           OL 064.5         1984.281         64         10         41         17.162470         0.027         6         10         16.92338         0.72           P 1042+071         1989.195         12         10         44         55.911251         0.036         6         55         38.26318         0.66           P 1044+719         1988.337         11         10         48         27.619911         0.117         71         43         35.93801         0.66           P 1055+01         1988.883         2635         10         58         29.605196         0.002         1         33         58.82394         0.08           P 1104-445         1987.230         132         11         7         8.694243         0.083         -44         49         7.62063         0.49	1022+194	GC 1022+19	1989,603	œ	10	24	44.809582	0.026	19	12	20.41663	0.53	-0.774
OL 064.5         1984.281         64         10         41         17.162470         0.027         6         10         16.92338         0.72           P 1042+071         1989.195         12         10         44         55.911251         0.036         6         55         38.26318         0.66           1 044+719         1988.317         11         10         48         27.619911         0.117         71         43         35.93801         0.66           1 055+01         1988.883         2635         10         58         29.605196         0.002         1         33         58.82394         0.08           1 044-445         1987.230         132         11         7         8.694243         0.083         -44         49         7.62063         0.49	1034 - 293	P 1034-293	1989.093	535	10	37	16.079710	0.009	-29	34	2.81403	0.14	-0.499
P 1042+071         1989.195         12         10         44         55.911251         0.036         6         55         38.26318         0.66           1044+719         1988.317         11         10         48         27.619911         0.117         71         43         35.93801         0.66           1         1988.883         2635         10         58         29.605196         0.002         1         33         58.82394         0.08           P 1104-445         1987.230         132         11         7         8.694243         0.083         -44         49         7.62063         0.49	1038+064	OL 064.5	1984.281	64	10	41	17.162470	0.027	9	10	16.92338	0.72	-0.603
1044+719     1988.317     11     10     48     27.619911     0.117     71     43     35.93801     0.66       P 1055+01     1988.883     2635     10     58     29.605196     0.002     1     33     58.82394     0.08       P 1104-445     1987.230     132     11     7     8.694243     0.083     -44     49     7.62063     0.49	1042+071	P 1042+071	1989.195	12	10	44	55.911251	0.036	9	55	38.26318	99.0	-0.875
P 1055+01 1988.883 2635 10 58 29.605196 0.002 1 33 58.82394 0.08 P 1104-445 1987.230 132 11 7 8.694243 0.08344 49 7.62063 0.49	1044+719	1044+719	1988.317	11	10	48	27.619911	0.117	71	43	35.93801	99.0	-0.479
P 1104-445 1987.230 132 11 7 8.694243 0.08344 49 7.62063 0.49	1055+018	P 1055+01	1988.883	2635	10	28	29.605196	0.002	-	33	58.82394	0.08	-0.424
	1104-445	P 1104-445	1987.230	132	11	~	8.694243	0.083	-44	49	7.62063	0.49	-0.877

Table 5 (contd)

GC IIII+14         1984-858         23         11         13         S& 60000         0.041         14         42           P III6+12         1985-652         131         11         13         S& 60000         0.041         14         42           P III6+12         1985-652         131         11         18         57,201376         0.043         12         34           P III77-14         1985-365         131         11         15         53,232653         0.004         -14         4           GC II28+38         1986-178         82         11         46         53,232653         0.005         -14         4           H144-02         1986-178         1002         11         17         47         1,370686         0.001         -14         4           P 1144-07         1988-107         7         11         47         1,370686         0.003         -1         2         1         4         1,370686         0.003         -1         2         1         4         1,370686         0.003         -1         2         1         4         1,370686         0.003         -1         2         1         1         4         1,370686         0.003 </th <th>IAU name</th> <th>Common name</th> <th>Mean observation</th> <th>Number of</th> <th>Righ</th> <th>Right ascension</th> <th>Error,</th> <th></th> <th>Declination</th> <th>ation</th> <th>Error,</th> <th>RA, dec.</th>	IAU name	Common name	Mean observation	Number of	Righ	Right ascension	Error,		Declination	ation	Error,	RA, dec.
GC IIII+14         1984.858         23         II         II         58.695090         0.041         14         42           P III5+12         1984.281         7         II         18         67.301376         0.043         12         34           P III77-14         1985.652         131         11         2         53.28563         0.023         38         15           III 24-07         1986.348         1082         11         30         53.28563         0.023         38         15           III 44-07         1986.134         1082         11         4         5.287935         0.066         39         58           III 44-00         1985.107         7         11         47         51.53597         0.066         39         58           II 44-00         1985.107         7         11         47         51.53597         0.073         17         14         17         11         47         51.53597         0.073         17         14         19         18         17         14         19         18         17         14         19         18         17         14         14         14         14         14         14         18<			epoch	observations			msec	ਚ	Е	asec	mas	correlation
P 11104-12         1984-281         7         11         18 57301376         0.043         12         34           P 1123-146         1985-622         131         11         25         53711910         0.010         26         10           P 1127-14         1985-623         131         11         25         53711910         0.010         26         10           GC 1128+38         1984-708         82         11         46         58-275735         0.006         39         58           H 144-402         1986-341         21         11         47         1-370866         0.041         38         15           P 1144-407         1986-347         21         11         47         1-370866         0.043         38         15           P 1144-407         1980-044         23         11         47         1-370866         0.043         38         15           ON 231         1980-043         13         11         47         1-370866         0.043         38         15           ON 231         1980-043         13         11         47         1-370866         0.04         24         17           ON 231         1980-042         1	1111+149	GC 1111+14	1984.858	23	11 1	3 58.695099		14	42	26.95282	0.62	-0.974
P 1129+26         1986.652         131         11         25         33.711910         0.010         26         10           GC 1128+38         1982.901         85         11         30         7,02541         0.004         -14         4           GC 1128+38         1984.798         82         11         46         58,297935         0.023         39         18           H44+402         1986.348         1986.151         211         11         47         1370006         0.041         -38         12           H44+402         1980.344         1983.347         21         11         47         1370006         0.041         -38         12           H144-402         1980.044         43         11         47         1370006         0.041         -38         13           H148-50         1980.041         43         11         47         1370006         0.041         -38         13           ON 231         1980.057         133         11         47         1370006         0.041         -38         13           P 1224-037         1983.348         1982         198         11         47         1370006         0.041         -38         1	1116+128	P 1116+12	1984.281	2				12	34	41.71983	0.71	-0.955
P 1127-14         1982-901         56         11         30         7.052-641         0.064         -14         49           GC 1128+38         1984-398         82         11         30         5.3288-53         0.023         38         15           1144-407         1986-348         1082         11         30         5.3288-53         0.023         38         15           P 1144-37         1986-347         211         11         47         1.3706-60         0.041         -38         15           P 1148-00         1989-093         211         11         47         1.3706-60         0.041         -38         15           ON 231         1989-093         1331         11         53         1.4290-04         0.041         -38         16           ON X231         1988-349         6         12         24         5.2487-7         0.004         29         17         46         4.2307-7         0.00         29         17         47         1.448-0         188         97         9         12         46         4.2307-7         0.00         29         14         47         1.448-0         188         97         1.448-0         188         18	1123+264	P 1123+26	1985.652	131				26	10	19.97890	0.17	-0.741
GC 1128+38         1984,798         82         11         30         53.282635         0.023         38         15           1144+402         1986,348         1082         11         46         58.297935         0.006         39         58           1144+402         1986,341         211         1         47         1.370696         0.041         -38         15           1144-071         1989,347         7         11         47         1.370696         0.003         -7         21           1150-4812         1989,044         1983,044         60         12         21         34.09044         0.102         -9         23           CC 1156+29         1980,051         113         12         21         34.09044         0.102         -9         23           ON 231         1980,967         13         11         5         31.24049         0.001         -9         14           P 1244-255         1985,767         118         12         4         4.223075         0.03         -3         3           P 1244-255         1985,767         118         12         4         4.232075         0.03         -1         4           P 1244-075	1127-145	P 1127-14	1982,901	56				-14	49	27.38946	0.99	-0.876
P 1144+402         1986.348         1002         11         46         58.297938         0.006         39         58           P 1144-071         1986.345         11         7         1.370566         0.041         -38         12           1146-071         1989.347         7         11         47         1.370566         0.041         -38         12           1146-071         1989.347         23         11         50         43.870846         0.045         -7         14           CC 1156+29         1989.044         43         11         53         12.49044         0.142         80         58           ON 231         1989.043         1331         11         53         12.490944         0.142         20         43.870846         0.041         29         14           ON 231         1980.57         119         12         24         5.241887         0.001         29         14           P 1244-072         1989.57         118         12         24         4.320767         0.03         20         14           P 1244-055         1989.567         1989.57         118         12         24         4.320767         10         24         <	1128+385	GC 1128+38	1984.798	82		-•		38	15	18.54746	0.50	-0.242
P 1144-579         1986.151         211         11         47         1370696         0.041         -38         12           P 1144-071         1989.367         7         11         47         51.55397         0.025         -7         24           P 1148-07         1989.367         43         11         53         12498944         0.075         -7         24           1150+812         1980.044         43         11         53         12498944         0.075         -7         24           ON 231         1980.571         113         12         21         31.63950         0.004         29         14           ON 231         1980.574         113         12         21         31.63956         0.016         28         13           3C 273         1985.374         1985.767         198         12         46         45.80166         0.03         -7         47           9 1244-255         1985.767         118         12         46         45.802166         0.03         -7         47           9 124-675         1985.767         118         12         46         45.802166         0.03         -7         47           9 1302-1002	1144+402	1144+402	1986.348	1082		-		39	28	34.30446	0.02	-0.066
H146-071         1989-367         7         11         47         51.553970         0.025         -7         24           P 1148-00         1983-107         23         11         50         43.870846         0.075         -0         23           I 13048-12         1980-044         43         11         53         12.490-044         0.01         29         14           GC 1156+29         1980-571         113         12         24         31.2490-04         0.01         29         14           ON 231         1980-571         113         12         24         52.421879         0.004         29         14           ON 231         1980-572         1130         12         24         52.421879         0.001         29         14           AC 273         1983-967         118         12         46         46.80216         0.003         -7         3           P 1244-072         1986-567         118         12         46.80216         0.003         -7         3           P 1344-055         1986-567         118         12         46.80216         0.003         -7         3           DV 326         1980-562         15         1	1144-379	P 1144-379	1986.151	211				-38	12	11.02475	0.36	-0.902
P 1146-00         1983-107         23         11         50         43.870846         0.075         -0         23           11504-812         1980.044         13         13         13         12.499044         0.142         80         58           GC 11564-29         1989.083         1331         11         53         12.499044         0.142         80         58           ON 231         1982.937         1983.849         60         12         24         52.421879         0.003         23         14           AC 273         1985.978         11902         12         24         52.421879         0.003         2         3           AC 273         1985.977         11902         12         24         66.99723         0.002         2         3           AC 279         1980.957         118         12         46         42.22075         0.003         -7         30           AC 279         1980.552         118         12         46         42.82076         0.004         -7         54         47           AC 279         1980.552         15         13         14         14         15         46         42.82077         0.004	1145 - 071	1145-071	1989.367	7-				2-	24	41.14088	0.71	-0.580
11504-812   1989.044   43   11   53   1249904   0.142   80   58   65   1989.083   1331   11   59   31.833910   0.004   29   14   1989.083   1331   11   59   31.833910   0.004   29   14   1989.987   1983.949   60   12   24   32.42187   0.031   2   3   3   3   3   3   3   3   3   3	1148-001	P 1148-00	1983.107	23				0-	23	54.20517	1.25	-0.891
GC 1156+29         1989 093         1331         11         59         31.833910         0.004         29         14           ON 231         1980.571         113         12         21         31.833910         0.004         29         14           P 1222+037         1983.849         60         12         24         52.431879         0.001         28         13           3 2 73         1983.978         1190         12         46         45.2421879         0.003         2         3           P 1243-072         1983.967         118         12         46         46.890216         0.037         -2         3           P 1244-255         1985.767         118         12         46         46.890216         0.003         -2         4           P 1302-102         1987.201         710         12         56         11.166497         0.003         -2         4           P 1302-102         1987.403         2312         13         4         46.802166         0.003         -2         4           OP-32         1987.403         2312         13         1         78.868379         0.004         -1         2         46.84152         0.003	1150+812	1150+812	1989.044	43				80	28	29.15409	0.33	0.247
ON 231         1980.571         113         12         21         31.690.65         0.016         28         13           9         273         1983.849         60         12         24         52.421879         0.031         3         30           123-273         1983.849         60         12         24         52.421879         0.031         3         30           1243-072         1989.997         11902         12         46         4.232075         0.002         2         3         30           P 1343-072         1989.997         118         12         46         46.802166         0.037         -25         47           P 1340-102         1989.652         15         13         46.802166         0.037         -25         47           P 1302-102         1989.652         15         13         16         28.653879         0.004         -25         47           P 1302-102         1980.151         13         16         28.653879         0.004         -25         47           OP -322         1984.363         45         13         16         7.864912         0.003         -12         47           GC 1342-663         198	1156+295	GC 1156+29	1989.093	1331				29	14	43.82693	90.0	-0.144
P 1222+037         1983.849         60         12         24         52.431879         0.031         3         3           3C 273         1985.978         11902         12         29         6699723         0.002         2         3           1243-072         1985.977         118         12         46         4.232075         0.002         2         3           P 1244-255         1985.771         710         12         46         4.232075         0.003         -5         47           3C 279         1987.721         710         12         56         11.166497         0.003         -5         47           P 1302-102         1989.652         15         13         16         7.865867         0.003         -5         47           P 1302-102         1980.585         13         16         7.865867         0.004         -10         -10         33           DOP-32         1980.285         13         16         7.865868         0.004         -12         47           DW 1335-12         1980.285         137         31         43         45.98962         0.004         -12         47         45.98962         0.004         -12         47	1219+285	ON 231	1980.571	113				28	13	58.50143	0.61	-0.639
3C 273         1985.978         11902         12         46         4.232075         0.002         2         30         4           124.3—072         1988.997         9         12         46         4.232075         0.023         -7         30         4           124.3—072         1988.997         9         12         46         46.32075         0.023         -7         30         4           3C 279         1985.721         710         12         5         11.166497         0.005         -5         47         4 <td>1222+037</td> <td>P 1222+037</td> <td>1983.849</td> <td>09</td> <td></td> <td></td> <td></td> <td>က</td> <td>30</td> <td>50.29426</td> <td>09.0</td> <td>-0.804</td>	1222+037	P 1222+037	1983.849	09				က	30	50.29426	09.0	-0.804
1243-072         1989.997         9         12         46         4.32075         0.023         -7         30           P 1244-255         1985.767         118         12         46         46.802166         0.037         -25         47           3C 279         1987.211         710         12         56         11.166497         0.005         -5         47           P 1302-102         1980.652         15         13         5         33.014919         0.019         -10         33           B2 1308+32         1987.403         2312         13         16         7.98592         0.004         32         20           OP -322         1980.151         4         13         17         36.49412         0.003         -3         38           OP 326         1980.151         4         13         17         36.49412         0.004         -12         57           GC 1342+662         1983.849         35         13         43         45.95862         0.004         -12         57           GC 1342+663         1988.839         16         13         4         45.95862         0.004         -12         57           GC 1340-19         198	1226+023	3C 273	1985.978	11902				2	က	8.59916	90.0	0.129
P 1244–255         1985.767         118         12         46         46.802166         0.037         -25         47           3C 279         1987.211         710         12         56         11.16497         0.005         -5         47           P 1302-102         1989.652         15         15         13         5         33.014919         0.009         -10         33           B 2 1308+32         1987.403         2312         13         16         7.885872         0.004         -10         33         20           OP -32         1980.151         4         13         17         36.494152         0.003         -3         38           OP -32         1980.285         1379         13         17         36.494152         0.003         -12         37           OP 326         1980.385         1379         13         4         45.959625         0.004         -12         57           OQ 1342+66         1984.363         15         13         4         45.959625         0.004         -12         57           OQ 2134-66         1986.707         739         13         57         4.43660         0.004         -12         57	1243-072	1243 - 072	1989.997	6				1-7	30	46.57384	0.39	-0.834
3C 279         1987.211         710         12         56         11.166497         0.005         -5         47           P 1302-102         1989.652         15         13         5         33.014919         0.004         32         20           P 1302-102         1989.652         1987.403         2312         13         16         28.663879         0.004         32         20           OP-322         1984.363         4         13         16         7.985952         0.093         -33         38           OP 326         1990.151         4         13         17         36.494152         0.035         -34         25           DW 135b-12         1983.849         35         13         43         45.959625         0.004         -12         57           GC 1342+662         1983.849         35         13         44         8.679707         0.034         6         6           GC 1342+663         1985.833         162         13         44         8.679707         0.034         -12         57           P 1349-439         1986.707         739         13         57         4.436650         0.006         19         10	1244 - 255	P 1244-255	1985.767	118				-25	47	49.29095	0.44	-0.922
P 1302-102         1989.652         15         13         5         33.014919         0.019         -10         33           B2 1308+32         1987.403         2312         13         10         28.663879         0.004         32         20           OP-322         1984.363         45         13         16         7.985952         0.093         -33         38           OP 326         1990.151         4         13         17         36.494152         0.035         34         25           DW 1335-12         1983.849         35         13         43         45.96962         0.094         -12         57           GC 1342+662         1984.708         162         13         44         8.67977         0.004         -12         57           GC 1342+663         1985.833         45         13         44         8.67977         0.034         -12         57           GC 1342+663         1986.833         45         13         44         8.67977         0.034         -12         57           P 1349-439         1986.833         162         13         4         8.67977         0.034         -1         52           OQ 208	1253-055	3C 279	1987.211	710				1.5	47	21.52418	0.16	0.153
B2 1308+32         1987 403         2312         13         10         28.663879         0.004         32         20           OP-322         1984.363         45         13         16         7.985952         0.093         -33         38           OP 326         1990.151         4         13         17         36.494152         0.093         -33         38           OP 326         1989.285         1379         13         37         39.782745         0.004         -12         57           GC 1342+662         1983.849         35         13         43         45.959625         0.002         66         2           GC 1342+663         1984.708         162         13         44         86.79707         0.04         -12         57           GC 1342+663         1985.833         45         13         52         56.535149         0.143         -44         12           P 1349-439         1986.707         739         13         57         44.36650         0.009         19         19           OQ 208         1986.855         1620         14         7         0.394422         0.002         28         7           P 1424-41 <t< td=""><td>1302 - 102</td><td>P 1302-102</td><td>1989.652</td><td>15</td><td></td><td></td><td></td><td>-10</td><td>33</td><td>19.42628</td><td>98.0</td><td>-0.738</td></t<>	1302 - 102	P 1302-102	1989.652	15				-10	33	19.42628	98.0	-0.738
OP-322         1984.363         45         13         16         7.985952         0.093         -33         38           OP 326         1990.151         4         13         17         36.494152         0.035         34         25           DW 1335-12         1989.285         1379         13         47         36.494152         0.004         -12         57           GC 1342+662         1983.849         35         13         43         45.959625         0.004         -12         57           GC 1342+663         1983.849         35         13         44         8.679707         0.034         66         6         2           GC 1342+663         1986.707         739         13         57         44.36650         0.002         19         19           P 1349-439         1986.707         739         13         57         4.436650         0.002         19         19           OQ 208         1986.855         16207         14         7         0.394422         0.002         18         27           P 1406-076         1988.701         7         14         8         56.481178         0.014         15         29           P 1424	1308+326	B2 1308+32	1987.403	2312				32	20	43.78286	90.0	-0.205
OP 326         1990.151         4         13         17         36.494152         0.035         34         25           DW 1335-12         1989.285         1379         13         37         39.782745         0.004         -12         57           GC 1342+662         1983.849         35         13         43         45.959625         0.062         66         2           GC 1342+662         1983.849         35         13         44         8.679707         0.034         66         6           P 1349-439         1985.833         45         13         52         56.535149         0.143         -44         12           P 1349-439         1986.707         739         13         57         44.36650         0.006         19         19           OP-192         1989.104         18         13         57         44.36650         0.002         19         19           OQ 208         1986.855         16207         14         7         0.394422         0.002         2         2           P 1406-076         1989.701         7         14         8         56.481178         0.014         54         23           P 1445-162         19	1313-333	OP-322	1984.363	45				-33	38	59.17341	1.00	-0.947
DW 1335-12         1980-285         1379         13         37         39.782745         0.004         -12         57           GC 1342+662         1983.849         35         13         43         45.959625         0.062         66         2           GC 1342+663         1984.708         162         13         44         8.679707         0.034         66         6           P 1349-439         1985.833         45         13         52         56.535149         0.143         -44         12           P 1354+19         1986.707         739         13         57         4.436650         0.006         19         19           OP-192         1988.855         16207         14         7         0.394422         0.002         -15         27           OQ 208         1986.855         16207         14         7         0.394422         0.002         28         27           P 1406-076         1988.701         7         14         8         56.481178         0.014         54         23           P 1424-41         1988.396         5         14         27         56.29781         0.132         -12         6           P 1443-162	1315+346	OP 326	1990.151	4				34	25	15.93075	1.46	0.839
GC 1342+662         1983.849         35         13         43         45.959625         0.062         66         2           GC 1342+663         1984.708         162         13         44         8.679707         0.034         66         6           P 1349-439         1985.833         45         13         52         56.535149         0.143         -44         12           P 1354+19         1986.707         739         13         57         44.36650         0.006         19         19           OP-192         1989.104         18         13         57         11.245065         0.029         -15         27           OQ 208         1986.855         16207         14         7         0.394422         0.029         -15         27           P 1406-076         1989.701         7         14         8         56.481178         0.03         -7         52           GC 1418+54         1988.396         5         14         27         56.297581         0.13         -4         23           P 1442-41         1988.3981         23         14         27         56.297581         0.03         -16         29           P 1443-162 <t< td=""><td>1335-127</td><td>DW 1335-12</td><td>1989.285</td><td>1379</td><td></td><td></td><td></td><td>-12</td><td>22</td><td>24.69304</td><td>0.10</td><td>-0.148</td></t<>	1335-127	DW 1335-12	1989.285	1379				-12	22	24.69304	0.10	-0.148
GC 1342+663         1984.708         162         13         44         8.679707         0.034         66         6           P 1349-439         1985.833         45         13         52         56.535149         0.143         -44         12           P 1354+19         1986.707         739         13         57         4.436650         0.006         19         19           OP-192         1989.104         18         13         57         11.245065         0.029         -15         27           OQ 208         1986.855         16207         14         7         0.394422         0.002         -15         27           P 1406-076         1989.701         7         14         8         56.481178         0.034         -7         52           GC 1418+54         1988.396         5         14         27         56.297581         0.132         -4         23           P 1424-41         1988.396         5         14         27         56.297581         0.132         -0         6           QQ-151         1983.981         23         14         45         55.376358         0.093         -16         29           P 1445-16         198	1342+662	GC 1342+662	1983.849	35				99	2	25.74482	0.44	-0.053
P 1349-439         1985.833         45         13         52         56.535149         0.143         -44         12           P 1354+19         1986.707         739         13         57         4.436650         0.006         19         19           OP-192         1989.104         18         13         57         11.245065         0.029         -15         27           OQ 208         1986.855         16207         14         7         0.394422         0.002         28         27           P 1406-076         1989.701         7         14         8         56.481178         0.034         -7         52           GC 1418+54         1988.396         5         14         27         56.29781         0.014         54         23           P 1424-41         1988.396         5         14         27         56.29781         0.132         -42         6           QQ-151         1983.981         23         14         32         57.690651         0.273         -18         1           1443-162         1989.518         12         4         24,979795         0.003         -16         29           P 15445-16         1988.423         2	1342+663	GC 1342+663	1984.708	162				99	9	11.64348	0.22	0.150
P 1354+19         1986.707         739         13         57         4,436650         0.006         19	1349-439	P 1349-439	1985.833	45			-	-44	12	40.39031	0.00	-0.890
OP-192       1989.104       18       13       57       11.245065       0.029       -15       27         OQ 208       1986.855       16207       14       7       0.394422       0.002       28       27         P 1406-076       1989.701       7       14       8       56.481178       0.034       -7       52         GC 1418+54       1985.652       531       14       27       56.29781       0.014       54       23         P 1424-41       1983.981       23       14       27       56.29781       0.132       -42       6         OQ-151       1983.981       23       14       32       57.690651       0.273       -18       1         1443-162       1989.518       12       14       45       53.376358       0.093       -16       29         P 1445-16       1988.423       2420       15       4       24,979795       0.003       10       29	1354+195	P 1354+19	1986.707	739				19	19	7.37252	0.11	-0.396
OQ 208       1986.855       16207       14       7       0.394422       0.002       28       27         P 1406-076       1989.701       7       14       8       56.481178       0.034       -7       52         GC 1418+54       1985.652       531       14       19       46.597424       0.014       54       23         P 1424-41       1988.396       5       14       27       56.297581       0.132       -42       6         OQ-151       1983.981       23       14       32       57.690651       0.273       -18       1         1443-162       1989.805       6       14       45       53.376358       0.093       -16       29         P 1445-16       1989.518       12       14       48       15.054192       0.035       -16       20         OR 103       103       1988.423       2420       15       4       24,979795       0.003       10       29	1354-152	OP-192	1989.104	18				-15	27	28.78804	0.38	-0.913
P 1406-076       1989.701       7       14       8       56.481178       0.034       -7       52         GC 1418+54       1985.652       531       14       19       46.597424       0.014       54       23         P 1424-41       1988.396       5       14       27       56.297581       0.132       -42       6         OQ-151       1983.981       23       14       32       57.690651       0.273       -18       1         1443-162       1989.805       6       14       45       53.376358       0.093       -16       29         P 1445-16       1988.423       2420       15       4       24.979795       0.003       10       29	1404+286	00, 208	1986.855	16207				28	27	14.68967	0.05	-0.291
GC 1418+54 1985.652 531 14 19 46.597424 0.014 54 23 P 1424-41 1988.396 5 14 27 56.297581 0.132 -42 6 OQ-151 1983.981 23 14 32 57.690651 0.273 -18 1 1443-162 1989.805 6 14 45 53.376358 0.093 -16 29 P 1445-16 1989.518 12 14 48 15.054192 0.035 -16 20 OR 103 1988.423 2420 15 4 24.979795 0.003 10 29	1406 - 076	P 1406-076	1989.701	7				2-	52	26.66544	0.54	-0.765
P 1424-41       1988.396       5       14       27       56.297581       0.132       -42       6         OQ-151       1983.981       23       14       32       57.690651       0.273       -18       1         1443-162       1989.805       6       14       45       53.376358       0.093       -16       29         P 1445-16       1989.518       12       14       48       15.054192       0.035       -16       20         OR 103       1988.423       2420       15       4       24,979795       0.003       10       29	1418+546	GC 1418+54	1985.652	531				54	23	14.78695	0.15	-0.163
OQ-151     1983.981     23     14     32     57.690651     0.273     -18     1       1443-162     1989.805     6     14     45     53.376358     0.093     -16     29       P 1445-16     1989.518     12     14     48     15.054192     0.035     -16     20       OR 103     1988.423     2420     15     4     24,979795     0.003     10     29	1424-418	P 1424-41	1988.396	52				-42	9	19.44042	0.87	-0.833
1443-162     1989.805     6     14     45     53.376358     0.093     -16     29       P 1445-16     1989.518     12     14     48     15.054192     0.035     -16     20     2       OR 103     1988.423     2420     15     4     24.979795     0.003     10     29     3	1430-178	0Q-151	1983,981	23				-18	Н	35.25099	3.75	-0.974
P 1445–16 1989.518 12 14 48 15.054192 0.035 –16 20 OR 103 1988.423 2420 15 4 24.979795 0.003 10 29	1443-162	1443-162	1989.805	9				-16	58	1.61882	1.25	-0.956
OR 103 1988.423 2420 15 4 24.979795 0.003 10 29	1445 - 161	P 1445-16	1989.518	12				-16	20	24.54957	0.50	-0.908
D 1504 101	1502+106	OR 103	1988.423	2420				10	53	39.19889	0.10	-0.081
F 1504-167 1984.760 64 15 7 4.786958 0.022 -16 52	1504 - 166	P 1504-167	1984.760	64	15	7 4.786958	0.022	-16	52	30.26719	0.63	-0.523

Table 5 (contd)

IAII name	Common name	Mean observation	Number of	<u> </u>	Right ascension	ension	Error,		Declination	ıtion	Error,	RA, dec.
		${f e}{f poch}$	observations	늄	mim	sec	msec	P	Е	asec	mas	correlation
1510-089	P 1510-08	1986.814	244	15	12	50.532932	0.013	6-1	2	59.82971	0.26	-0.707
1511 - 100	P 1511-100	1989.405	6	15	13	44.893406	0.027	-10	12	0.26344	0.58	-0.671
1514-241	P 1514-24	1989.545	10	15	17	41.813305	0.058	-24	22	19.47806	0.70	-0.952
1519-273	P 1519-273	1986.975	180	15	22	37.676056	0.049	-27	30	10.78650	0.57	-0.938
1532+016	P 1532+01	1988.806	16	15	33	52.453609	0.034	1	31	4.20772	0.53	-0.908
1548+056	DW 1548+05	1986.819	2423	15	20	35.269226	0.003	ıçı	27	10.44892	0.09	0.113
1555+001	DW 1555+00	1985.066	96	15	22	51.433945	0.025	0-	-	50.41273	0.61	-0.651
1611+343	DA 406	1989.841	1744	16	13	41.064259	0.003	34	12	47.90900	0.08	-0.171
1614+051	P 1614+051	1988.544	13	16	16	37.556808	0.028	4	29	32.73700	0.45	-0.875
1622 - 253	P 1622-253	1990.195	525	16	25	46.891602	0.007	-25	27	38.32558	0.28	-0.341
1633+382	GC 1633+38	1988.861	5684	16	35	15.492970	0.003	38	œ	4.50046	90.0	-0.070
1637+574	P 1637+574	1983.521	271	16	38	13.456281	0.021	57	20	23.97837	0.24	0.038
1638+398	NRAO 512	1983.405	119	16	40	29.632765	0.021	33	46	46.02849	0:30	-0.599
1642+690	1642+690	1980.699	1079	16	42	7.848453	0.015	89	26	39.75576	0.10	-0.060
1641 + 399	3C 345	1985.825	19307	16	42	58,809959	0.002	39	48	36.99369	90.0	-0.008
1655+077	OS 092	1987.989	27	16	28	9.011436	0.025	2	41	27.54106	0.71	-0.579
1656+053	DW 1656+05	1982.948	20	16	28	33.447254	0.117	s	15	16.44569	1.76	-0.992
1657 - 261	P 1657-261	1985.153	39	17	0	53.154152	0.046	-26	10	51.72603	0.63	-0.855
1706 - 174	OT-111	1984.986	41	17	6	34.345371	0.048	-17	28	53.36405	0.77	-0.881
1717+178	GC 1717	1981.466	25	17	19	13.048463	0.030	17	45	6.43817	1.60	0.058
1730 - 130	NRAO 530	1987.879	1156	17	33	2.705772	0.005	-13	4	49.54746	0.14	-0.183
1738+476	OT 465	1985.490	93	17	39	57.129055	0.023	47	37	58.36189	0.57	-0.243
1739+522	4C 51.37	1989.997	2728	17	40	36.977840	0.004	52	11	43.40747	90.0	0.066
1741 - 038	P 1741-038	1988.664	5917	17	43	58.856140	0.002	-3	20	4.61590	0.10	0.135
1748+701	1749+701	1982.658	138	17	48	32.840473	0.064	20	S	50.76680	0.27	-0.053
1749+096	OT 081	1987.660	1447	17	51	32.818584	0.003	6	33	0.72882	0.10	0.061
1803+784	1803+784	1987.488	23352	18	0	45.683819	600.0	78	28	4.01828	0.04	0.075
1807+698	3C 371	1984.948	238	18	9	50.680634	0.038	69	49	28.10885	0.20	-0.021
1821+107	P 1821+10	1985.019	45	18	24	2.855270	0.034	10	44	23.77293	1.38	-0.523
1845+797	3C 390.3	1979.901	16	18	42	8.989495	0.362	79	46	17.12646	0.58	-0.118
1908-201	0V - 213	1986.907	32	19	11	9.652929	0.035	-20	9	55.10953	0.47	-0.901
1920 - 211	0V - 235	1988.276	37	19	23	32.189861	0.030	-21	4	33.33339	0.43	-0.897
1921 - 293	0V - 236	1988.921	1040	19	24	51.055946	900'0	-29	14	30.12061	0.15	-0.252
1923+210	OV 239.7	1987.244	88	19	25	59.605373	0.016	21	9	26.16149	0.26	-0.799
1928+738	1928+738	1981.460	51	19	27	48.494961	0.089	73	28	1.57013	0.71	-0.293
1936 - 155	P 1936-15	1988.959	16	19	33	26.657772	0.031	-15	25	43.05868	0.48	-0.886
				8								

Table 5 (contd)

1989,128	IAU name	Common name	Mean observation	Number of	Rig	Right ascension	ension	Error,		Declination	ation	Error,	RA, dec.
99 (4+5) 3         1989 (238)         24         19         55         427.39186         0.043         51         45.4822           9 (VV 537)         1986 (238)         119         20         0         57.000448         0.023         -17         48         57.50048           9 (W 537)         1986 (344)         20         2         6.681649         0.027         -17         48         57.50240           1 (W 537)         1981 (500)         14         20         2         6.681649         0.027         -17         48         57.50240           1 (W 537)         1981 (500)         14         20         31         47.98549         0.027         -17         48         31.49858           2 (A 18)         1982 (500)         33         20         38         37.03479         0.010         20         31.49858         31.4488         31.4			uooda	observations		nin'	sec	msec	P	E	asec	mas	correlation
OV—198         1986-285         119         20         0         57.090488         0         57.090488         0         57.090488         1         15.75799         0         7.757947         0         2         2         6.81649         0         2         1         15.75797         -1         4         4.02305         0         0         5.75797         -1         4         4.02305         0 <t< td=""><td>1954+513</td><td>1954+513</td><td>1989.238</td><td>24</td><td>19</td><td>55</td><td>42.738186</td><td>0.043</td><td>51</td><td>31</td><td>48.54832</td><td>0 48</td><td>0.006</td></t<>	1954+513	1954+513	1989.238	24	19	55	42.738186	0.043	51	31	48.54832	0 48	0.006
P 2008—159         P 368844         20         20         11 15710927         0.027         -15         46         40.2356           O We S27         OWE S27         OWE S27         188 844         20         21         56.846         0.022         61         36         58.9081           O W 521         1 184 0023         33         20         31         54.99428         0.022         61         36         58.9081           2 C 113         1 1884 003         35.9         20         31         54.99428         0.002         12         13.8684           3 C 2113+29B         1 1886 107         37.8         20         31         54.99428         0.002         12         13.8684           9 P 2134-001         1 1888 881         2         21         2.94442         0.002         1.2         1.45660           1 P 2134-004         1 1885 882         2         21         2.94456         0.002         1.2         1.45660           1 P 2134-004         1 1885 883         2         21         2.84868         0.002         1.2         1.45680           1 P 2134-004         1 1885 383         2         21         2.848683         0.01         1.457830	1958-179	OV-198	1986.285	119	20	0	57.090458	0.023	-17	48	57.67260	0.33	-0.855
OW 637         1987-616         101         20         6681649         0.025         61         36         88.0481           P 2020+121         POW 637         1881-630         14         20         31         47.58549         0.027         51         13         13.488           P 2020+121         1898.150         359         20         38         37.03473         0.010         21         15         13.488           O V 2046         1898.150         359         20         38         37.03473         0.010         21         15         13.488           O V 2056         1898.835         21         21         15         24.14457         0.001         21         33         33.36867           P 2113+004         1988.885         26         27         34         10.049620         0.01         21         35         11.45840           P 213+004         1988.885         26         21         34         10.049620         0.01         21         31.47384           P 2134+00         1985.323         245         21         34         10.049620         0.01         21         31.4438           O X 082         1985.220         28         37.815862	2008 - 159	P 2008-159	1988.844	20	20	11	15.710927	0.027	-15	46	40.25305	0.42	-0.868
P. M. S51         1981.630         14         20         31         47.38849         0.197         54         55         3.14788           1 3 C. 184.033         3.3         20         38         4.438458         0.062         12         19         13.3864           2 C. 184.033         3.59         20         38         4.4377380         0.010         29         33         3.048           2 C. 188.134         1988.317         178         21         1.5         2.44377380         0.010         29         33         3.36657           2 C. 188.134         1988.831         2.0         38         2.261684         0.01         29         32         2.03376           3 C. 186.142         1988.832         2.0         38         2.858638         0.01         29         3.5         2.03376           4 C. 184.404         1988.832         2.0         38         2.858638         0.00         0.01         2.1         4.758484           5 C. 234.404         1988.832         2.0         38         2.858638         0.00         1.1         4.138484           6 C. 234.406         1988.406         2.0         38         2.858638         0.00         2.0         4.131	2021+614	OW 637	1987.616	101	20	22	6.681649	0.032	61	36	58.80481	0.50	-0.009
P 2009+121         1984,093         33         20         31         54,94238         0.062         12         19         41,3396.3           2 44,113-49         1988,150         1388,150         38         37,04478         0.010         51         19         11,529           9 CX 036         1388,213         1388,233         21         13         35,1138         0.010         29         37,0448         0.010         29         37,0448           1 P 2113-1-021         1388,833         21         23         4,41738         0.010         29         37,0448           1 P 2131-021         1388,835         26         21         23         4,41738         0.010         29         37,0448           1 P 2145+06         1388,843         24         21         38,58508         0.002         0.01         41,57540           2 CX 00 00         2 S 13,440         1886,403         245         21         48,58508         0.002         0.01         41,3536           2 CX 00 00         2 S 13,442         2         21         48,58508         0.002         0.02         1         41,3536           2 CX 00 00         2 S 13,442         2         2         2         2	2030+547	OW 551	1981.630	14	20	31	47.958549	0.197	54	55	3.14788	3.01	080-0
2 A C 418         1988.150         359         20         38         37.034779         0.010         51         19         12.66291           A S 11134-29B         1988.137         580.07         59         37.03473         0.010         29         33         23.06677           A S 1134-29B         1988.881         20         21         31         32.51684         0.025         -1         7         47.5540           P 2128-12         1988.885         25         25         21         31         32.561684         0.025         -1         3         22.561684         0.025         -1         3         47.55808         0.002         -1         3         22.561684         0.035         -1         3         47.55808         0.002         -1         3         22.561684         0.035         -1         47.55808         0.002         -1         47.55806         0.002         -1         47.55806         0.002         -1         47.55806         0.002         -1         47.55806         0.002         -1         47.55806         0.002         -1         47.55806         0.002         -1         47.55806         0.002         -1         47.54441         0.008         -1         1         47.54	2029+121	P 2029+121	1984.093	33	20	31	54.994236	0.062	12	19	41.33965	1.26	-0.715
8 2 2113+29B         1986-307         178         21         15         29.413473         0.010         29         33         38.30657           0 X0 36         1988-107         5008         21         23         44.517380         0.002         5         3         22.00376           1 P 2138-0.1         1988-883         25         2         21         34         10.309582         0.002         -1         7         4.79540           1 P 2138-0.1         1988-885         6648         21         36         35.58630         0.002         -0         41         4.79540           1 P 2134-004         1986-433         245         21         36         35.58630         0.002         -0         41         4.79540           2 P 2134-004         1986-433         245         21         35         35.58630         0.003         -1         37.44341           2 P 2134-004         1986-130         1986-130         2         2         24.321930         0.003         -1         41.43540           3 P 216-03         1986-220         2         2         2         47.22914         0.003         -1         37.4441           3 C 2234-63         1988-220         10	2037+511	3C 418	1988.150	359	20	88	37.034779	0.010	51	19	12.66291	0.11	0.217
0 X 036         1889,107         5908         21         23         44,317380         0.002         5         22,09376           1 P 2128-12         1988,833         21         21         31         35,581684         0.005         -1         7         4,79540           1 P 2131-021         1988,835         25         21         31         35,581684         0.002         -1         31         1,79540           1 P 2131-021         1988,835         245         21         36         36,88300         0.002         -1         31         1,75540           2 P 2145+06         1986,433         245         21         48         5,48668         0.002         -1         31         1,75540           3 OX -192         1986,433         245         21         48         5,48668         0.003         -1         1         41,43730           4 OX -192         1986,403         22         2         4,27437         0.003         -1         5         36,64960           5 D 220+03         1988,433         24         22         2         47,53671         -1         37,6494           5 D 2227-03         1988,433         16         22         2         47,53674 <td>2113+293</td> <td>B2 2113+29B</td> <td>1986.307</td> <td>178</td> <td>21</td> <td>15</td> <td>29.413473</td> <td>0.010</td> <td>59</td> <td>33</td> <td>38.36657</td> <td>0.23</td> <td>-0.162</td>	2113+293	B2 2113+29B	1986.307	178	21	15	29.413473	0.010	59	33	38.36657	0.23	-0.162
P 2128—12         1988.831         21         21         31         35.261684         0.025         -12         7         4.79540           P 2134—021         1988.885         25         21         34         10.309592         0.016         -1         53         17.23844           P 2134+004         1988.885         6648         21         34         10.309592         0.016         -1         53         17.23844           P 2134+004         1988.855         6648         21         34         10.309592         0.016         -1         53         17.23844           P 2145+06         1986.403         24         21         34         10.30958         6         71         34.24658         6         6         71         35.24443           V VO 082         1986.403         1562         22         24.37973         0.039         -1         1         35.2844           V VO 122.01         1985.374         68         22         22         4.37973         1         35.3848           P 2216-03         1988.475         1988.452         16         22         23         4.466890         -1         31.34378           P 2217-08         1988.112         12 <td>2121+053</td> <td>OX 036</td> <td>1989.107</td> <td>5908</td> <td>21</td> <td>23</td> <td>44.517380</td> <td>0.002</td> <td>ъ</td> <td>35</td> <td>22.09376</td> <td>0.08</td> <td>0.113</td>	2121+053	OX 036	1989.107	5908	21	23	44.517380	0.002	ъ	35	22.09376	0.08	0.113
P 7131-021         1988 885         25         21         34         10.309859         0.016         -1         53         17.23844           I P 7131+004         1985.852         6648         21         36         38.586308         0.002         0         41         54.1443           P 2145+06         1986.362         2454         21         36         38.586308         0.002         0         41         54.1443           O X 082         1986.140         1986.260         245         21         36         3.858638         0.002         0         41         54.1443           O X 082         1986.260         1986.403         15662         22         2         43.291370         0.003         42         1         32.3844           D VEOLIST         1986.274         68         22         2         47.29977         0.003         42         1         32.3844           P P 2227-08         1988.355         19         22         2         40.084297         0.026         9         41         34.4341           P P 2227-08         1988.735         118         22         2         40.084297         0.026         42         35.43421           C A 446	2128-123	P 2128-12	1988.831	21	21	31	35.261684	0.025	-12	7	4.79540	0.41	-0.849
P 2134+004         1985-852         6648         21         36         38.58630         0.002         0         41         54.1443           P 2145-06         1986-433         2454         21         48         5.48668         0.003         6         57         38.0450           OX 982         1984.142         78         21         51         37.875381         0.039         5         21.35050           OX -192         1985.200         1985.200         1985.200         1985.200         24         22         2         43.291370         0.003         42         19.359008           BD 2201+31A         1985.204         1985.204         1985.204         24         22         2         43.29170         0.003         42         1         93.29360           BD 2201+31A         1985.204         22         2         41.97580         0.003         42         1         41.97580         3         46.87671           BD 2221-03         1988.515         1988.515         12         2         2         47.239274         0.003         41         51.3028           CTA 102         1988.112         12         2         2         2         4         4         5	2131-021	P 2131-021	1988.885	25	21	34	10.309592	0.016	-1	53	17.23844	0.32	-0.759
P 2145+06         1986433         2454         21         48         5.48668         0.003         6         57         38.60450           OX 082         1984.142         78         21         51         37.875381         0.039         -15         12.96605           OX -192         1986.260         1986.260         51         12         56         6.281944         0.003         -15         1         9.32834           OX -192         1986.403         15662         2         2         4.375370         0.003         -15         1         9.32834           P 2216-03         1986.403         15662         2         2         4.975830         0.033         -1         1         9.32834           P 2216-03         1986.20374         6         2         2         4.06842         2         3         14.97580         9         4         3.28344           P 2227-08         1988.433         16         2         2         4.068498         0.018         -1         3         2.0439           C 22 24         1         1         2         2         2         4.068498         0.018         4         7         1.3908           C 22 3	2134+004	P 2134+004	1985.852	6648	21	98	38.586308	0.002	0	41	54.21443	0.10	-0.111
OX 082         1984.142         78         21         51         37.875381         0.03         5         52.95605           OX -192         1985.260         51         21         58         6.281964         0.089         -15         1         9.32834           VRO 42.22.01         1986.403         1562         22         2         4.2197830         0.038         31         45         39.8806           P 2216-03         1985.274         68         22         18         52.03716         0.003         -3         45         39.8806           P 2216-03         1985.274         68         22         18         52.03716         0.003         -4         15         3.9.8806           P 2216-03         1985.274         68         22         23         47.89827         0.018         -4         45         38.2049           P 2227-08         1988.423         19         22         29         40.084297         0.026         -8         37.4341           2224-695         1988.423         11         22         24         10.240809         0.013         45         36.0439           CTA 102         1988.735         122         24         18.21963	2145+067	P 2145+06	1986.433	2454	21	48	5.458668	0.003	9	22	38.60450	0.08	0.102
OX-192         1985.260         51         21         58         6.281964         0.089         -15         1         9.32834           VRO42.22.01         1986.403         15662         22         2         43.291370         0.003         42         16         39.98008           B 2 201+31A         1983.433         24         22         3         14.975830         0.038         31         45         38.2049           B 2 201+31A         1985.274         68         22         25         47.29274         0.018         -4         57         1.39028           P 2 277-08         1988.423         16         22         25         47.289274         0.018         -4         57         1.39028           C 2 239+695         1988.423         16         22         29         40.084297         0.026         -8         25         4.438989           C TA 102         1988.735         125         22         29         40.084297         0.026         -8         57.4339           OY-172.6         1988.135         121         22         36         22.40861         0.03         28         57.1359           OY-172.6         1988.145         121         22	2149+056	OX 082	1984.142	78	21	51	37.875381	0.039	S	52	12.95605	0.63	-0.873
VRO 42.22.01         1986-403         15662         22         4.3.291370         0.003         42         16         39.98008           B 2 2201+31A         1983-433         24         22         3         14.975830         0.038         31         45         38.98008           B 2 2201+31A         1983-433         24         22         3         14.975830         0.038         31         45         38.27049           B 2 2201-08         1988-735         28         22         25         47.295774         0.013         -4         57         1.39028           P 2 227-08         1988-855         1988-855         16         22         29         40.084297         0.026         -8         35         36.87697           C 2 234+28         1988-735         125         22         29         40.084297         0.026         -8         37.47329         0.033         11         43         50.4321           C A 1 102         1985-112         121         22         36.408969         0.013         11         43         50.4321           C C 2234+28         1986-112         121         22         24         18.231953         0.019         -12         21         22.470861 </td <td>2155-152</td> <td>OX-192</td> <td>1985,260</td> <td>51</td> <td>21</td> <td>28</td> <td>6.281964</td> <td>0.089</td> <td>-15</td> <td>-</td> <td>9.32834</td> <td>1.26</td> <td>-0.961</td>	2155-152	OX-192	1985,260	51	21	28	6.281964	0.089	-15	-	9.32834	1.26	-0.961
B2 2201+31A         1983.433         24         22         3         14.975830         0.038         31         45         38.27049           B 2216-03         1987.052         2789         22         18         52.037716         0.003         -3         35         36.87867           3 446         1985.274         68         22         25         47.259274         0.018         -4         57         1.39028           9 2229-695         1988.855         19         22         29         40.084297         0.018         -4         57         1.39028           1	2200+420	VRO 42.22.01	1986.403	15662	22	2	43.291370	0.003	43	16	39.98008	0.04	0.405
P 2216 – 03         1987 055         2789         22         18         52.037716         0.003         -3         35         36.87867           3C 446         1985.274         68         22         25         47.259274         0.018         -4         57         1.39028           9 C 246         1988.855         1988.855         19         22         29         40.084297         0.026         -8         32         54.43421           1 C 24 102         1988.423         125         22         36.468952         0.022         6         46         28.07718           1 C 2234+28         1988.135         125         22         36.408969         0.013         11         43         50.9439           1 C 2234+28         1988.112         121         22         36.40899         0.013         11         43         51.2657           1 C 2234+28         1986.145         12         24         18.24789         0.019         -12         6         12.7557           2 C 253+41         1986.145         1386.146         28         36.707783         0.045         -2         5.2         48         38.85780         0.019         -1         6         12.7553	2201+315	B2 2201+31A	1983.433	24	22	က	14.975830	0.038	31	45	38.27049	0.70	0.170
3C 446         1985.274         68         22         25         47.259274         0.018         -4         57         1.39028           P 2227-08         1988.855         19         22         29         40.084297         0.026         -8         32         54.43421           CZ29+695         1988.423         16         22         30         36.469852         0.026         -8         32         54.43421           CTA 102         1985.129         125         22         32         36.408909         0.013         11         43         50.0439           CTA 102         1988.735         125         22         32         36.408909         0.013         11         43         50.0439           OVY-1726         1988.735         121         22         36         22.470861         0.003         28         57.41339           OVY-1726         1988.145         121         22         46         18.231953         0.019         -12         6         51.27657           OVY-1726         1988.145         1386.145         138         22         48         38.685780         0.019         -12         6         51.27657           GC 2254+07         1988.146	2216-038	P 2216-03	1987.052	2789	22	18	52.037716	0.003	-3	35	36.87867	0.10	0.068
P 2227-08         1988.855         19         22         29         40.084297         0.026         -8         35         54.4321           2299+695         1988.423         16         22         30         36,46985         0.092         69         46         28.07718           CTA 102         1985.129         125         22         32         36,46985         0.092         69         46         28.07718           GC 2234+28         1985.129         125         22         36         22,470861         0.003         28         28         57.41359           OV-172.6         1988.112         121         22         36         22,470861         0.003         28         28         57.41359           OV-172.6         1984.167         65         22         48         38.685780         0.019         -12         6         51.27657           P 2245-328         1986.145         13876         22         53         57.747932         0.019         -12         6         51.5382           GC 2253+407         1988.149         19         22         53         17.5303083         0.15         7         43         17.51163           P 2255-282         1990.205 <td>2223-052</td> <td>3C 446</td> <td>1985.274</td> <td>89</td> <td>22</td> <td>25</td> <td>47.259274</td> <td>0.018</td> <td>-4</td> <td>57</td> <td>1.39028</td> <td>0.40</td> <td>-0.687</td>	2223-052	3C 446	1985.274	89	22	25	47.259274	0.018	-4	57	1.39028	0.40	-0.687
2229+695         1988-423         16         22         30         36.469852         0.092         69         46         28.07718           CTA 102         1985.129         125         22         32         36.408909         0.013         11         43         50.90439           CTA 102         1988.735         1182         22         36         22.470861         0.003         28         28         57.41359           CC 2234+28         1988.735         121         22         36         22.470861         0.003         28         28         57.41359           OV-172.6         1985.112         121         22         36         22.470861         0.003         28         28         57.41359           OV-172.6         1986.145         121         22         48         38.685780         0.0045         -12         6         51.27557           GC 2254+07         1986.144         4         22         57         17.303083         0.159         7         43         12.30326           GC 2254+07         1988.749         19         22         57         17.553122         0.047         2         43         17.51163           P 2255-282         1990.205 <td>2227-088</td> <td>P 2227-08</td> <td>1988,855</td> <td>19</td> <td>22</td> <td>53</td> <td>40.084297</td> <td>0.026</td> <td>∞ I</td> <td>32</td> <td>54.43421</td> <td>0.43</td> <td>-0.891</td>	2227-088	P 2227-08	1988,855	19	22	53	40.084297	0.026	∞ I	32	54.43421	0.43	-0.891
TCTA 102         1985.129         125         22         36,408909         0.013         11         43         50,90439           GC 2234+28         1988.735         3182         22         36         22,470861         0.003         28         28         57,1359           OY-172.6         1985.112         121         22         46         18.231953         0.019         -12         6         51,27657           OY-172.6         1985.112         121         22         46         18.231953         0.019         -12         6         51,27657           P 2245-328         1984.167         65         22         48         38.685780         0.045         -32         35         52,18752           GC 2254+07         1986.145         13876         22         53         57.74793         0.043         42         2         52.53282           GC 2254+07         1989.614         4         22         57         17.303083         0.159         7         43         12.3163           P 2254+024         1988.749         19         22         57         17.563122         0.047         2         43         17.51163           P 2254-028         1988.376         2	2229+695	2229+695	1988.423	16	22	30	36.469852	0.092	69	46	28.07718	0.39	0.065
GC 2234+28         1988.735         3182         22         36         22.470861         0.003         28         57.41359           OY-172.6         1985.112         121         22         46         18.231953         0.019         -12         6         51.27657           P 2245-328         1984.167         65         22         48         38.685780         0.045         -12         6         51.27657           9 2245-328         1984.167         65         22         48         38.685780         0.045         -12         6         51.27657           9 C 2253-41         1986.145         13876         22         53         57.74793         0.004         42         2         55.35800           GC 2254+07         1988.749         1988.749         19         22         57         17.303083         0.159         7         43         12.30326           P 2255-282         1990.205         405         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         2         56         5962849         0.008         -27         58         17.553122           GC 2318+04	2230+114	CTA 102	1985.129	125	22	32	36.408909	0.013	11	43	50.90439	0.24	-0.734
OY—172.6         1985.112         121         22         46         18.231953         0.019         —12         6         51.27657           P 2245—328         1984.167         65         22         48         38.685780         0.045         —22         35         57.74793         0.002         16         8         53.56100           3C 454.3         1986.145         13876         22         53         57.74793         0.002         16         8         53.56100           GC 2253+41         1983.351         54         22         55         36.707783         0.043         42         2         55.36200           GC 2254+07         1989.614         4         22         57         17.303083         0.159         7         43         12.30326           P 2254-024         1988.749         19         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         22         58         5.962849         0.008         -27         58         17.55389           GC 2318+04         1988.370         24         23         23         23         23.553376         0.025         5	2234+282	GC 2234+28	1988.735	3182	22	36	22.470861	0.003	28	28	57.41359	90:0	0.197
P 2245-328         1984.167         65         22         48         38.685780         0.045         -32         35         52.18752           3C 454.3         1986.145         13876         22         53         57.747932         0.002         16         8         53.56100           GC 2253+41         1983.351         54         22         55         36.707783         0.043         42         2         52.53282           GC 2254+07         1989.614         4         22         57         17.303083         0.159         7         43         12.30326           P 2254-224         1988.749         19         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         22         57         17.563122         0.047         2         43         17.51163           GC 2318+04         1988.370         24         23         5         5.962849         0.008         -27         58         21.25589           GC 2318+04         1988.570         89         23         23         31.953726         0.024         -2         30         57.62940           P 2355-16         1984.839	2243-123	OY - 172.6	1985.112	121	22	46	18.231953	0.019	-12	9	51.27657	0.32	-0.826
3C 454.3       1986.145       13876       22       53       57.747932       0.002       16       8       53.56100         GC 2253+41       1983.351       54       22       55       36.707783       0.043       42       2       52.53282         GC 2254+07       1989.614       4       22       57       17.303083       0.159       7       43       12.30326         P 2254+024       1988.749       19       22       57       17.563122       0.047       2       43       17.51163         P 2255-282       1990.205       405       22       57       17.563122       0.047       2       43       17.51163         P 2350-035       1988.970       24       23       50       44.856579       0.008       -27       58       21.25589         P 2330-035       1985.216       89       23       23       31.953726       0.024       -3       17       5.02289         P 2335-027       1988.570       8       23       37       57.339039       0.069       -2       30       57.62940         P 2355-166       1988.367       9       23       54       30.196244       0.071       -15       13       11	2245-328	P 2245-328	1984.167	65	22	48	38.685780	0.045	-32	32	52.18752	0.49	-0.914
GC 2253+41         1983.351         54         22         55         36.707783         0.043         42         2         55.3282           GC 2254+07         1989.614         4         22         57         17.303083         0.159         7         43         12.30326           P 2254+024         1988.749         19         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         22         58         5.962849         0.008         -27         58         21.25589           GC 2318+04         1988.970         24         23         20         44.856579         0.025         5         13         49.95361           P 2320-035         1985.216         89         23         23         31.953726         0.024         -3         17         5.02289           P 2335-027         1989.570         8         23         37         57.339039         0.069         -2         30         57.62940           P 2345-16         1988.367         9         23         54         30.195244         0.071         -15         13         11.21327           P 2355-106         1987.771 <td>2251+158</td> <td>3C 454.3</td> <td>1986.145</td> <td>13876</td> <td>22</td> <td>53</td> <td>57.747932</td> <td>0.002</td> <td>16</td> <td>œ</td> <td>53.56100</td> <td>0.05</td> <td>0.315</td>	2251+158	3C 454.3	1986.145	13876	22	53	57.747932	0.002	16	œ	53.56100	0.05	0.315
GC 2254+07         1989.614         4         22         57         17.303083         0.159         7         43         12.30326           P 2254+024         1988.749         19         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         22         58         5.962849         0.008         -27         58         21.25589           GC 2318+04         1988.970         24         23         20         44.856579         0.025         5         13         49.95361           P 2330-035         1985.216         89         23         23         31.953726         0.024         -3         17         5.02289           P 2335-027         1989.570         8         23         37         57.339039         0.069         -2         30         57.62940           P 2355-16         1984.839         71         23         48         2.608478         0.071         -15         13         11.21327           P 2355-106         1987.771<	2253+417	GC 2253+41	1983.351	54	22	22	36.707783	0.043	42	7	52.53282	0.97	0.032
P 2254+024         1988.749         19         22         57         17.563122         0.047         2         43         17.51163           P 2255-282         1990.205         405         22         58         5.962849         0.008         -27         58         21.25589           GC 2318+04         1988.970         24         23         20         44.856579         0.025         5         13         49.95361           P 2320-035         1985.216         89         23         23         31.953726         0.024         -3         17         5.02289           P 2335-027         1989.570         8         23         37         57.339039         0.069         -2         30         57.62940           P 2345-16         1984.839         71         23         48         2.608478         0.038         -16         31         12.21206           P 2355-106         1987.701         40         23         54         30.195244         0.071         -15         13         11.2137	2254+074	GC 2254+07	1989.614	4	22	22	17.303083	0.159	7	43	12.30326	2.56	-0.962
P 2255-282         1990.205         405         22         58         5.962849         0.008         -27         58         21.25589           GC 2318+04         1988.970         24         23         20         44.856579         0.025         5         13         49.95361           P 2320-035         1985.216         89         23         23         31.953726         0.024         -3         17         5.02289           P 2335-027         1989.570         8         23         37         57.339039         0.069         -2         30         57.62940           P 2345-16         1984.839         71         23         48         2.608478         0.038         -16         31         12.02106           P 2355-106         1987.701         40         23         54         30.195244         0.071         -15         13         11.2137	2254+024	P 2254+024	1988.749	19		57	17.563122	0.047	7	43	17.51163	0.70	-0.945
GC 2318+04     1988.970     24     23     20     44.856579     0.025     5     13     49.95361       P 2320-035     1985.216     89     23     23     31.953726     0.024     -3     17     5.02289       P 2335-027     1989.570     8     23     37     57.339039     0.069     -2     30     57.62940       P 2345-16     1984.839     71     23     48     2.608478     0.038     -16     31     12.02106       2351-154     1989.367     9     23     54     30.195244     0.071     -15     13     11.21327       P 2355-106     1987.701     40     23     56     10.0026     -2     0.002     0.000	2255-282	P 2255-282	1990.205	405		28	5.962849	800.0	-27	28	21.25589	0.33	-0.183
P 2320-035       1985.216       89       23       23       31.953726       0.024       -3       17       5.02289         P 2335-027       1989.570       8       23       37       57.339039       0.069       -2       30       57.62940         P 2345-16       1984.839       71       23       48       2.608478       0.038       -16       31       12.02106         2351-154       1989.367       9       23       54       30.195244       0.071       -15       13       11.21327         P 2355-106       1987.701       40       23       69       10.0026       0.03       10.0026       0.03       10.0026       0.0026	2318+049	GC 2318+04	1988.970	24		20	44.856579	0.025	ĸ	13	49.95361	0.38	-0.904
P 2335-027     1989.570     8     23     37     57.339039     0.069     -2     30     57.62940       P 2345-16     1984.839     71     23     48     2.608478     0.038     -16     31     12.02106       2351-154     1989.367     9     23     54     30.195244     0.071     -15     13     11.21327       P 2355-106     1987.701     40     23     56     10.0026     0.021     10     0.0026	2320-035	P 2320-035	1985.216	83		23	31.953726	0.024	-3	17	5.02289	0.40	-0.885
P 2345–16 1984.839 71 23 48 2.608478 0.038 –16 31 12.02106 2351–154 1989.367 9 23 54 30.195244 0.071 –15 13 11.21327 P 2355–106 1987.701 40 23 58 10.002025 0.021 40 0.020	2335-027	P 2335-027	1989.570	80			57.339039	0.069	-2	30	57.62940	1.09	-0.917
2351-154 1989.367 9 23 54 30.195244 0.071 -15 13 11.21327 P 2355-106 1987.701 40 23 69 10.00326 0.023 10.00326	2345-167	P 2345-16	1984.839	71	•	48	2.608478	0.038	-16	31	12.02106	0.56	-0.898
P 2355-106 1987 701 40 23 58 10 883 30 30 30 30 30 30 30 30 30 30 30 30 30	2351 - 154	2351-154	1989.367	6			30.195244	0.071	-15	13	11.21327	1.02	-0.948
10.58 02 01-35 0.033 -10 20 8.61091	2355 - 106	P 2355-106	1987.701	40	23	28	10.882395	0.033	~10	20	8.61091	0.55	-0.844

Table 6. JPL 1990-3 celestial ephemeris pole motion model

Period, days	$\Delta A_{\psi}$ (in phase) (out of phase), nrad	$\Delta A_c$ (in phase) (out of phase), nrad
6798.38	$-22.1\pm1.7$ $7.7  0.7$	8.2±0.3 10.3 0.2
3399.19	$7.8\pm0.6$ $1.0  0.3$	0.6±0.1 0.7 0.1
365.26	$24.6 \pm 0.1$ $5.5  0.1$	9.3±0.1 -0.9 0.1
182.62	$6.9 \pm 0.1$ -6.1 0.1	$-2.4\pm0.1$ $-1.9$ 0.1
121.75	$-1.0\pm0.1$ $0.1$ $0.1$	$0.8\pm0.1$ $0.1$ $0.1$
27.55	$-1.0\pm0.1$ -0.6 0.1	$-0.5 \pm 0.1$ $0.4  0.1$
13.66	$-2.7 \pm 0.2$ $0.6  0.2$	$1.4\pm0.1$ $-0.4$ 0.1
13.63	$-2.0\pm0.2$ $0.1  0.2$	$0.6 \pm 0.1$ $0.3  0.1$
433.20	$-3.0\pm0.1$ $3.0  0.1$	$-0.6\pm0.1$ $-1.3$ 0.1
	-10.4±0.3	_
	-61.3±1.6	9.4±0.3
	days  6798.38  3399.19  365.26  182.62  121.75  27.55  13.66  13.63	Period, (in phase) days (out of phase), nrad  6798.38   -22.1±1.7

Table 7. Comparisons of other JPL catalogs with JPL 1990-3

Catalog	1987-1	1991-1
Number of common sources	103	208
RMS uncertainty for common sources		
JPL 1990-3: RA $\cos\delta$ and dec., nrad	5.0, 4.4	6.3, 5.4
Other: RAcos $\delta$ and dec., nrad	9.0, 8.6	4.8, 4.0
Rotational offsets, $nrad x$	-2.8	0.0
y	7.2	1.8
z	-3.1 0.5	
$\chi^2$ per degree of freedom	1.7 1.5	
RMS difference, nrad: RA $\cos \delta$	7.5	5.2
dec.	10.8	5.8
$\chi^2$ per degree of freedom: RA $\cos \delta$	2.0	1.8
dec.	1.3	1.1

Table 8. Comparisons of external catalogs with JPL 1990-3

Catalog	IERS90	GSFC89	GSFC90
Number of common sources	183	120	159
RMS uncertainty for common sources			
JPL 1990-3: RA $\cos\delta$ and dec., nrad	4.9, 4.3	4.7, 3.6	6.1 4.8
Other: RAcos $\delta$ and dec., nrad	7.6, 6.8	5.7, 3.0	3.7 2.9
Rotational offsets, nrad x	1.4	10.2	-5.4
y	0.7	5.0	-11.9
2	0.3	-24.3	1.8
$\chi^2$ per degree of freedom	3.6	2.7	3.8
RMS difference, nrad: RA $\cos \delta$	5.8	4.2	7.5
dec.	8.9	6.2	6.6
$\chi^2$ per degree of freedom: RA $\cos \delta$	3.3	2.1	4.0
dec.	4.0	2.7	3.3

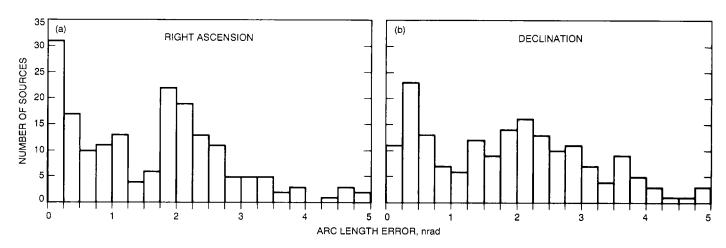


Fig. 1. Distribution of errors in (a) right ascension (arc length) and (b) declination for source coordinates in the catalog JPL 1990-3.

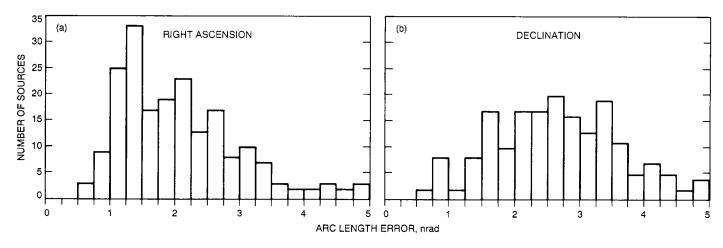


Fig. 2. Distribution of errors in (a) right ascension (arc length) and (b) declination for source coordinates in the TEMPO catalog JPL 1991-1.